

Site:	Carrier
Break:	6.4
Other:	v1

**CARRIER COLLIERVILLE SITE  
REMEDIAL DESIGN WORK PLAN**

**Prepared for:  
Carrier Corporation  
97 South Byhalia Road  
Collierville, Tennessee 38017**

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**APRIL 11, 1994**



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## Table of Contents

1.0	INTRODUCTION	1
2.0	PROJECT BACKGROUND	2
2.1	Site History	2
2.2	Physical Site Characteristics	6
2.3	Nature and Extent of Contamination	8
3.0	PROJECT DESCRIPTION	17
3.1	SOW Task I: Project Planning	17
3.2	SOW Task II: Remedial Design	17
3.3	Deliverables	18
3.4	Sequencing of Remedial Design Activities	19
4.0	PROJECT MANAGEMENT PLAN	21
4.1	Schedule	21
4.2	Organization	21
4.3	Data Management Plan	21
4.4	Status Reports	21
4.5	Meetings and Presentations	24
4.6	Community Relations Support Activities	24

## List of Figures

Figure 1-1	Vicinity Map	3
Figure 1-2	Site Plan	4
Figure 1-3	TCE Isopleths	10
Figure 1-4	TCE Isopleths	11
Figure 1-5	TCE Isopleths	12
Figure 1-6	TCE Isopleths	13
Figure 4-1	Schedule	22
Figure 4-2	Organizational Chart	23

## List of Appendices

Appendix A	Soils Treatability Study Work Plan
Appendix B	Groundwater Monitoring Work Plan
Appendix C	Field Sampling and Analysis Plan
Appendix D	Quality Assurance Project Plan
Appendix E	Health and Safety Plan

## 1.0 INTRODUCTION

This work plan has been developed per the Statement of Work (SOW) for Remedial Design and Remedial Action (RD/RA) for the Carrier Collierville site. This plan presents results of SOW Task I project planning activities and details efforts to be performed under SOW Task II remedial design activities. The plan has been prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the Superfund Amendments and Reauthorization Act of 1986 (SARA). It is based upon the findings of the Remedial Investigation (RI) and Feasibility Study (FS), and decisions regarding remedial actions that were presented by the United States Environmental Protection Agency (USEPA) in the *Carrier Air Conditioning Superfund Site Record of Decision* (ROD), September 3, 1992.

Design, implementation, construction, operation, monitoring, and maintenance of all components of the remedial activities as they apply to the contaminated soils and groundwater treatment will be in accordance with all applicable or relevant and appropriate regulations (ARARs) and all requirements identified pursuant to the ROD. These ARARs are identified in Section 10.2 of the ROD.

### Objectives

This project will address the contaminated soils near the Main Plant Area (MPA) and the former sludge lagoon at the North Remediation Site (NRS) and the contaminated groundwater plume within the Memphis Sand aquifer. The objectives of remedial design activities are as follows:

- To gather information and design a full-scale soils remediation system capable of achieving remedial goals as specified in the ROD.
- To assess the performance of the existing Memphis Sand groundwater extraction system, and the treatability testing conducted at the NRS.
- To assess, select, and design alternative actions to be taken if groundwater monitoring indicates changes to the groundwater remediation are necessary to achieve remedial goals.
- To establish means for verifying remedy performance.

## **2.0 PROJECT BACKGROUND**

The following is a restatement of site history, setting, and conditions as documented in the RI/FS and ROD. Please refer to those reports and associated references for details.

### **2.1 Site History**

#### ***Location and Land Use***

The Collierville Site is located on the western side of Collierville in Shelby County, Tennessee. The county is located in the southwest portion of the state, bounded to the north by Tipton County, to the east by Fayette County, to the south by DeSoto County, Mississippi, and to the west by the Mississippi River. The site is located at 97 S. Byhalia Road, near the intersection of Poplar Avenue (U.S. Highway 72) and Byhalia Road. Collierville is located approximately 21 miles east of downtown Memphis, Latitude 35°02'33," Longitude 89°41'00." The site is located on the Collierville Quadrangle, USGS Topographic Map. Figure 1-1 is a location map showing the Collierville Site and vicinity. Figure 1-2 shows the site and characteristics.

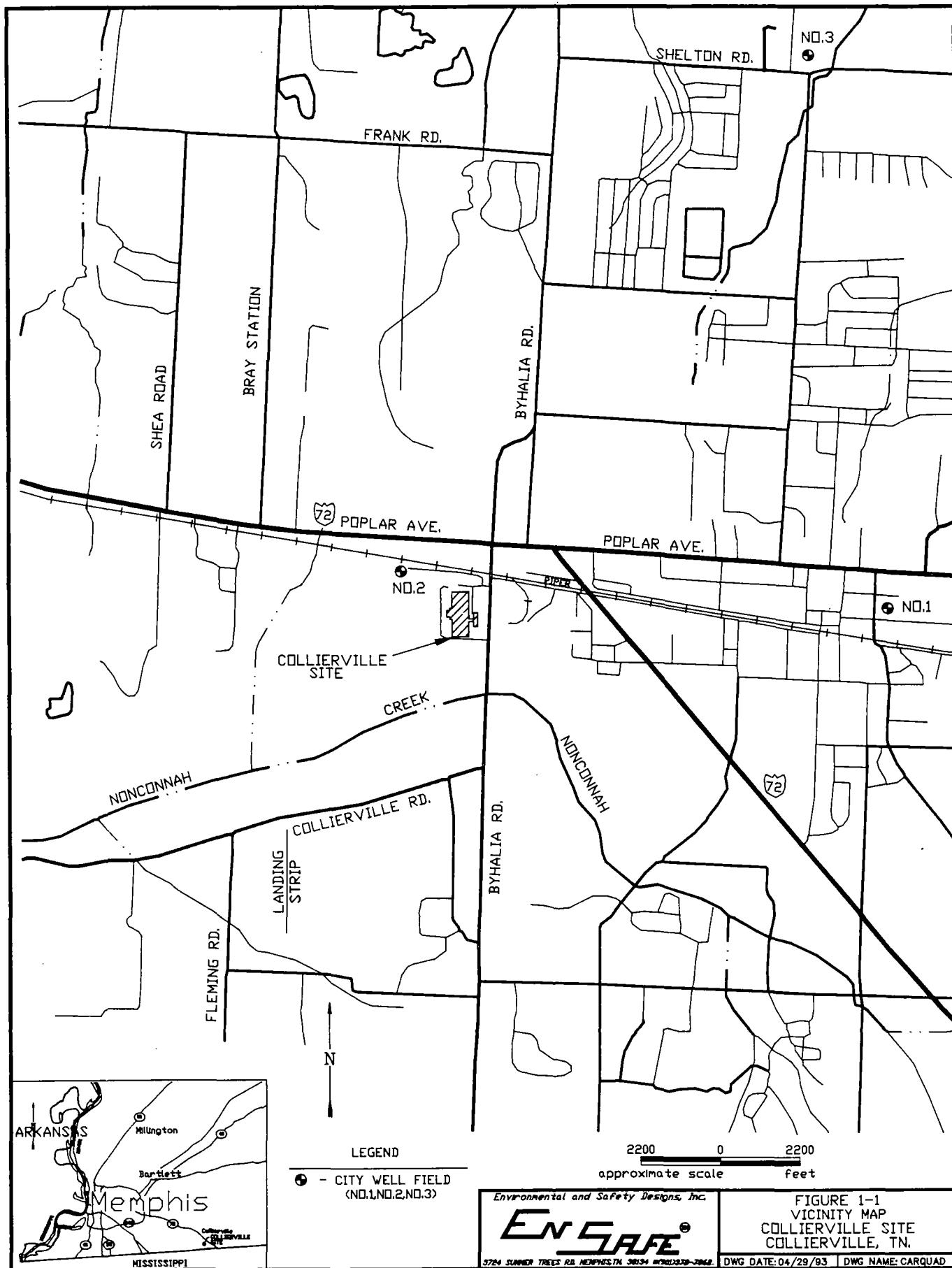
In 1967, the town of Collierville installed a well field for potable water on the northwest corner of the site. The operation consists of two wells, described as the West City Well and the East City Well, a treatment (aeration and chlorination) plant, and a storage tank. This area is identified as Water Plant 2 and pumps up to 1.4 million gallons per day of potable water to the town of Collierville. Although pumping rates vary depending upon demand, both wells are operational and currently in service.

Except for the city well field, the site was essentially farmland prior to development in 1969 by the Carrier Corporation. This land use description would include all areas immediately surrounding the facility. Current land use in the immediate area varies from industrial/commercial to undeveloped.

#### ***Facility Operations and History***

The site consists of approximately 135 acres owned principally by Carrier Corporation which operates a manufacturing plant on the property. Carrier, an air conditioning equipment manufacturer, developed the property in 1969-1970 and began manufacturing in 1971.





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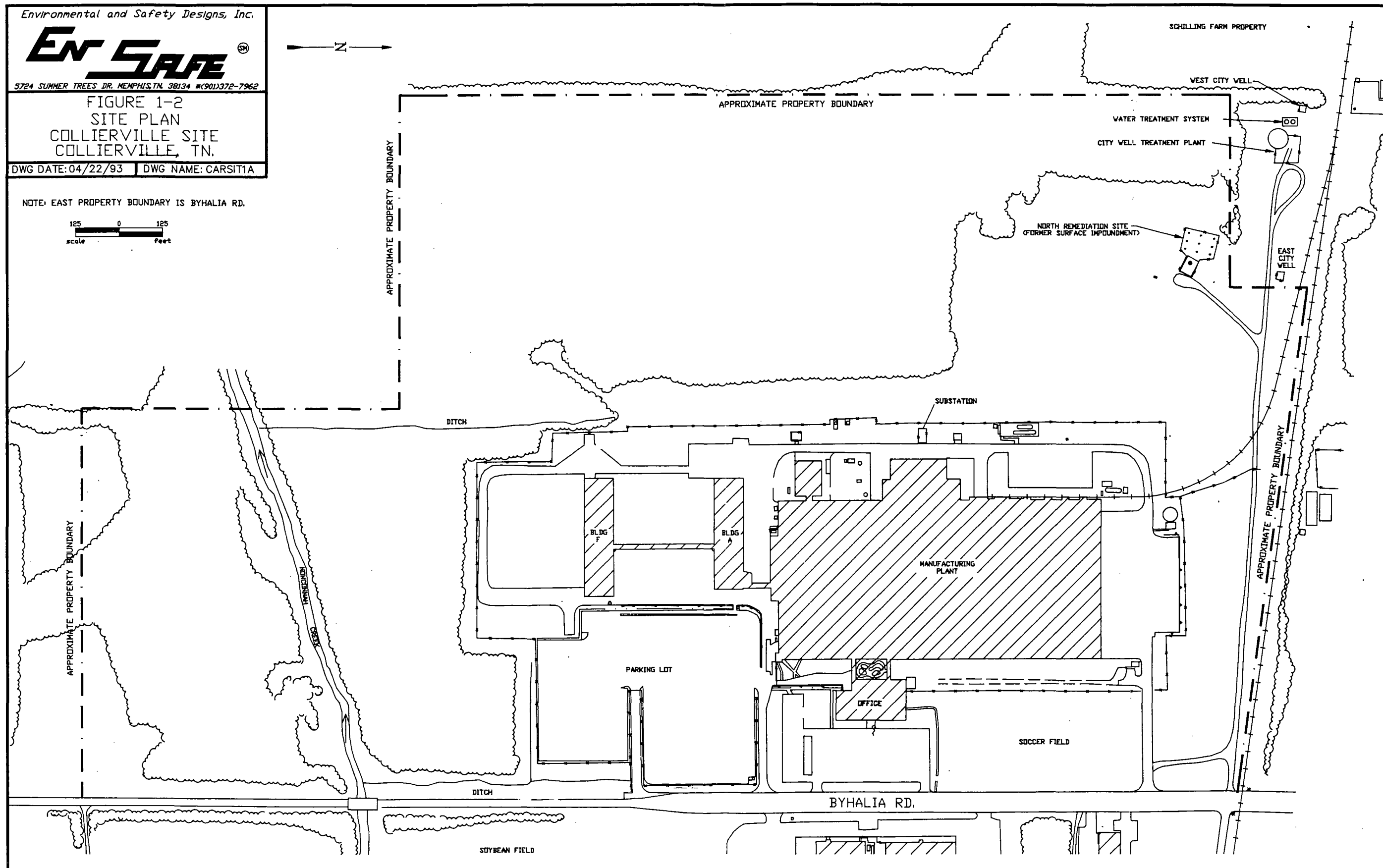
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FIGURE 1-2  
SITE PLAN  
COLLIERVILLE SITE  
COLLIERVILLE, TN.

DWG DATE: 04/22/93 DWG NAME: CARST1A

NOTE: EAST PROPERTY BOUNDARY IS BYHALIA RD.

125 0 125  
scale feet



Carrier's use consists primarily of four buildings: the main plant which is an assembly plant for air conditioning units, two smaller buildings to the south (formerly identified as the A and F buildings), and an office building.

About 1972, Carrier installed a wastewater surface impoundment on the northwest corner of the property. Data from the state's site investigation report indicate that the surface impoundment was approximately 50' by 48' and contained less than 1 foot of clarifier pit sludge at the time it was excavated in 1980. According to plant personnel, the sludge consisted mainly of an alkaline zinc phosphate washer sludge.

In 1979, the Carrier plant experienced a spill of trichloroethylene from a heated degreasing unit located on the south side of the plant. The spill occurred as a result of the failure of a filter cover on the unit. At the time of the spill, it was estimated that several thousand gallons of trichloroethylene were lost. The relative losses to air, ground, and surface water are unknown.

On January 23, 1985, Carrier experienced a second release of trichloroethylene as a result of a pipe failure associated with an above-ground tank. An estimated 500 gallons were lost.

#### ***Previous Removal/Remedial Actions***

Carrier Corporation has taken a number of steps to remove/eliminate sources of TCE and reduce the impact of prior releases. Following the 1979 spill, a large area of asphalt pavement and underlying soil was excavated and disposed offsite before the area was repaved.

After the 1985 release, Carrier initiated a massive soil excavation and testing program to remove TCE and TCE-contaminated soils from the impact area.

Sludge contained in the former lagoon was excavated in 1980 and shipped offsite for disposal. In 1989, Carrier installed a groundwater recovery and soil treatment system to remove TCE-contaminated groundwater and vapors from the area of the former surface impoundment.

In 1990, Carrier and the town of Collierville designed and installed an air stripping tower system at the Water Plant 2. This system removes TCE from raw water prior to entry into the chlorination system and subsequent distribution. The treatment system was designed to handle

incoming TCE concentrations of up to 200  $\mu\text{g}/\ell$ . Sampled effluent from the treatment system has been consistently below the detection limit of 2  $\mu\text{g}/\ell$ . Design, construction, and operation of this system was coordinated with and approved by the Tennessee Department of Water Supply (which permits water treatment systems), the Memphis-Shelby County Health Department, Bureau of Pollution Control (which has delegated authority for air emissions permitting), the State of Tennessee Division of Superfund, and the Town of Collierville. EPA, Region IV, was informed and concurred in the action.

## 2.2 Physical Site Characteristics

### *Geology and Physiography*

The Memphis/Shelby County area is situated in two major physiographic subdivisions: the Mississippi Alluvial Plain and the Gulf Coastal Plain section. The Collierville Site is located in the Gulf Coastal Plain section which is distinguished by gently rolling topography and a characteristic thick layer of loess deposited during Pleistocene glaciation. Anomalous areas of loess deposition are associated with alluvial plains of Mississippi River tributaries that cross the area. These rivers include the Wolf River, the Loosahatchie River, and Nonconnah Creek. Nonconnah Creek runs through and adjacent to the Collierville Site boundaries.

### *Hydrogeology*

Unconsolidated deposits up to 3000 feet deep overlie the bedrock in the Memphis/Shelby County area. The sediments consist principally of sand, clay, gravel, silt, and some lignite. The principal freshwater aquifers in the Memphis/Shelby County area are:

- Alluvium and Fluvial (terrace) deposits
- Memphis Sand
- Fort Pillow Sand

The alluvium and fluvial deposits are separated in most areas from the Memphis Sand by the Jackson-upper Claiborne confining layer (locally referred to as the Jackson Clay). The Memphis Sand and the Fort Pillow Sand are separated by the Flour Island confining layer.

### ***Shallow Groundwater***

For purposes of addressing the site investigation and remediation, two aquifer units have been identified: (1) intermittent shallow water in the alluvial and fluvial deposits overlying the Jackson Clay, and (2) the Memphis Sand aquifer. The alluvium and fluvial deposits show inconsistencies throughout the region. Shallow groundwater occurrence is intermittent due to undulations in the surface of the Jackson Clay layer and recharge from episodes of precipitation. These undulations capture and direct percolating groundwater to create shallow streams along the top of the clay layer. A local topographic high in the Jackson Clay exists in the northwest portion of the site. The clay surface slopes radially away from the high, resulting in radial movement of shallow groundwater away from the high.

The presence of some hydraulic connection between this shallow water and the underlying Memphis Sand aquifer is an important factor at the site. Although regionally present, the Jackson Clay is not uniformly a confining unit in and around the site. Graham and Parks (1986) suggest that the areal differences in the Jackson's ability to retard movement between the shallow groundwater and the Memphis Sand is directly associated with the aggregate thickness of clay beds within the unit, which ranges from 0 to 250 feet.

The Jackson Clay apparently thins to non-existence between the MPA and Nonconnah Creek to the south and Byhalia Road to the east, resulting in a direct exchange of groundwater between the shallow aquifer, where present, and the deeper Memphis Sand aquifer in the eastern and southern portions of the site. Field logging of this limit of the Jackson Clay agrees with reports of the Collierville Site lying in the outcrop area of the Memphis Sand.

### ***Memphis Sand Aquifer***

The Memphis Sand is a regressive thick-bedded sand unit deposited in near-shore to back-beach deltaic and alluvial environments. Oscillations of sea level in the Mississippi Embayment resulted in the grading of rivers and streams and the accumulation of this thick mass of coastal Claiborne Sand. The Memphis Sand consists of massive beds of fine to coarse-grained well-rounded to sub-angular sand and gravels intercalated with thin lenses and beds of silt, clay and argillaceous, micaceous and lignitic materials [Moore, 1965; Hosman, et al. 1968]. The sand lacks invertebrate fossils but remnants of well developed flora are present. The interbedded clay/silt layers are up to 20 feet thick but appear to have only a local affect on hydraulics in the

Memphis Sand. General strike is N-NE, dip is to the west towards the Mississippi River and total thickness generally varies from 500 to 850 feet. The Memphis Sand unconformably overlies the Eocene Flour Island Formation. The aquifer piezometric surface indicates flow at the site in the north to northwest direction.

The Memphis Sand and equivalent deposits are confined throughout most of the Memphis area, except in the east and southeastern portions of Shelby County. The Fort Pillow Sand is artesian throughout the Memphis area including the Collierville Site. Vertical interaquifer exchange between the Memphis Sand and the Fort Pillow Sand is restricted by the low hydraulic conductivity associated with the Flour Island confining layer.

### ***Meteorology***

Collierville's climate is typical of the Memphis region which is humid with summer temperatures ranging from the low 80s°F to 100°F; and winter temperatures in the 40s°F. Average humidity is 50 to 60 percent. Average rainfall is 56 inches per year. Evapotranspiration averages 40 inches per year [Tennessee Department of Health and Environment (TDHE), 1986].

Average wind speed is 10 miles per hour in winter and 7 miles per hour in summer. Predominant wind direction is north-northeast [TDHE, 1986].

## **2.3 Nature and Extent of Contamination**

### ***Contaminants of Concern***

Results of the Collierville Site investigation show varying levels of TCE contamination on the property. Results from soil and groundwater sample analyses, and soil-vapor screening data confirm that the two spill areas and the former lagoon area are sources of contamination of site soils and groundwater.

On July 15, 1986, the Town of Collierville's West Well in Well Field 2 adjacent to the site was sampled by TDHE and found to contain TCE. Since then, raw water TCE concentrations have gradually increased, and in 1990 air stripping towers were installed at the town water plant to remove the TCE. Recent analyses (from samples obtained quarterly since November 1990) have shown values of TCE in the untreated water from the West Well ranging from 45 to 290  $\mu\text{g}/\ell$ . Values in the East Well have ranged from 5 to 34  $\mu\text{g}/\ell$  before treatment over the same period.

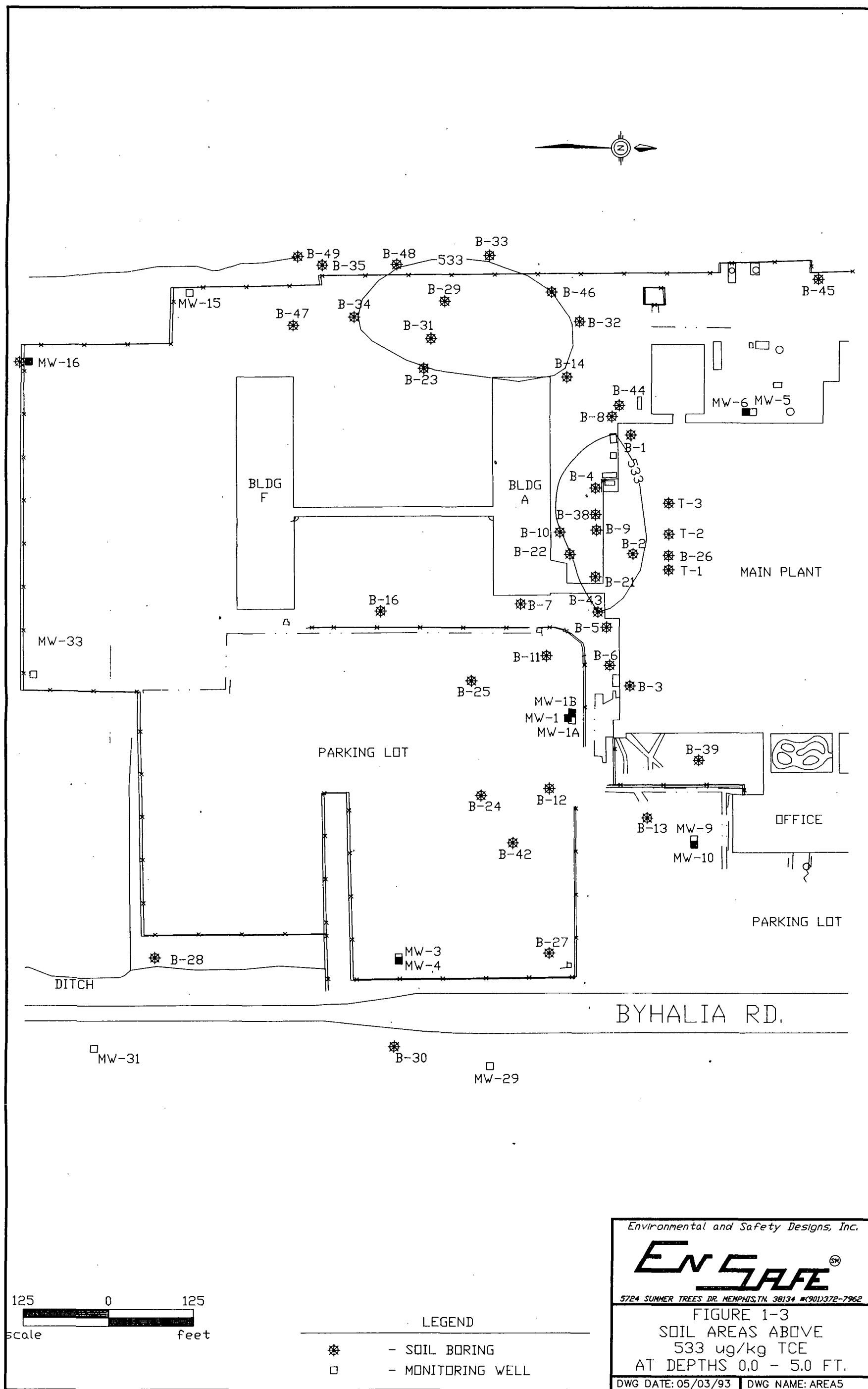
Values in treated water (before chlorination) averaged  $4 \mu\text{g}/\ell$  prior to the installation of the treatment system to remove TCE, and have since been consistently less than the detection limit of  $2 \mu\text{g}/\ell$ .

In addition to the Town of Collierville's Well Field 2, 15 private wells have been identified by TDHE within three miles of the site. Analyses of these wells by TDHE in September and October 1986, were negative for TCE to a detection limit of  $0.1 \mu\text{g}/\ell$ . [TDHE, 1986]. Private wells were again sampled in the RI with no TCE detected at a detection limit of  $5 \mu\text{g}/\ell$ .

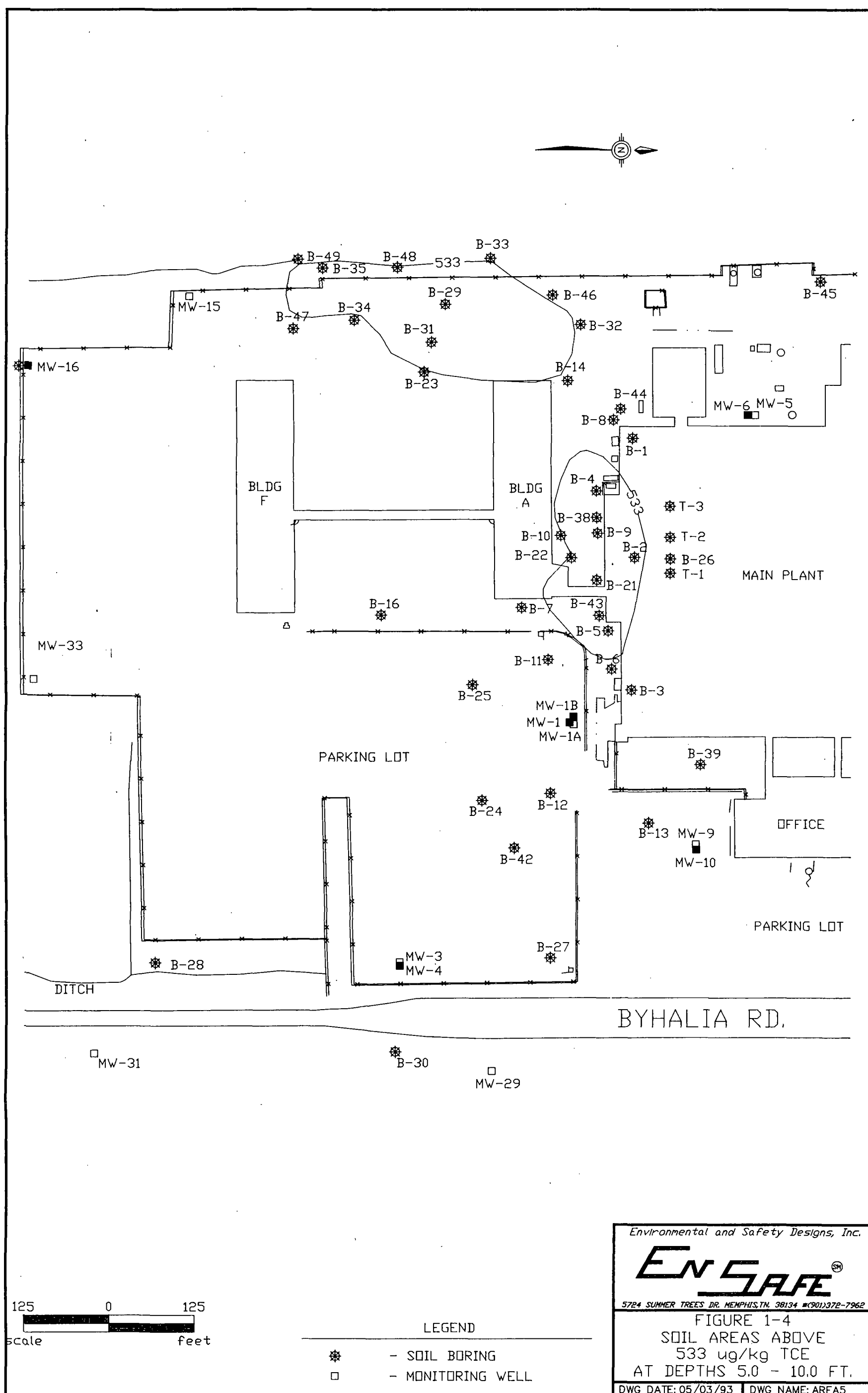
Soil samples collected within areas suspected to be impacted by spills indicate a wide range of levels of contamination. Samples from these areas ranged in concentration from  $< 0.5 \mu\text{g}/\text{kg}$  to  $1,550,000 \mu\text{g}/\text{kg}$  TCE. The greatest concentrations (B-4, B-9, B-21, and B-38) were from those areas more directly associated with the 1979 degreaser spill. The vertical extent of TCE contamination varies throughout the site. Soil screening methods indicate that many of the sample's concentration levels decrease with depth. However, some samples indicate an increase in concentrations approaching the zone of saturation in the shallow aquifer. Soil samples collected from the former lagoon area (borings B-17, B-18, B-19, and B-40) confirm the presence of TCE. Figures 1-3, 1-4, 1-5, and 1-6 show isopleths of TCE concentration in soils at different depths at the site.

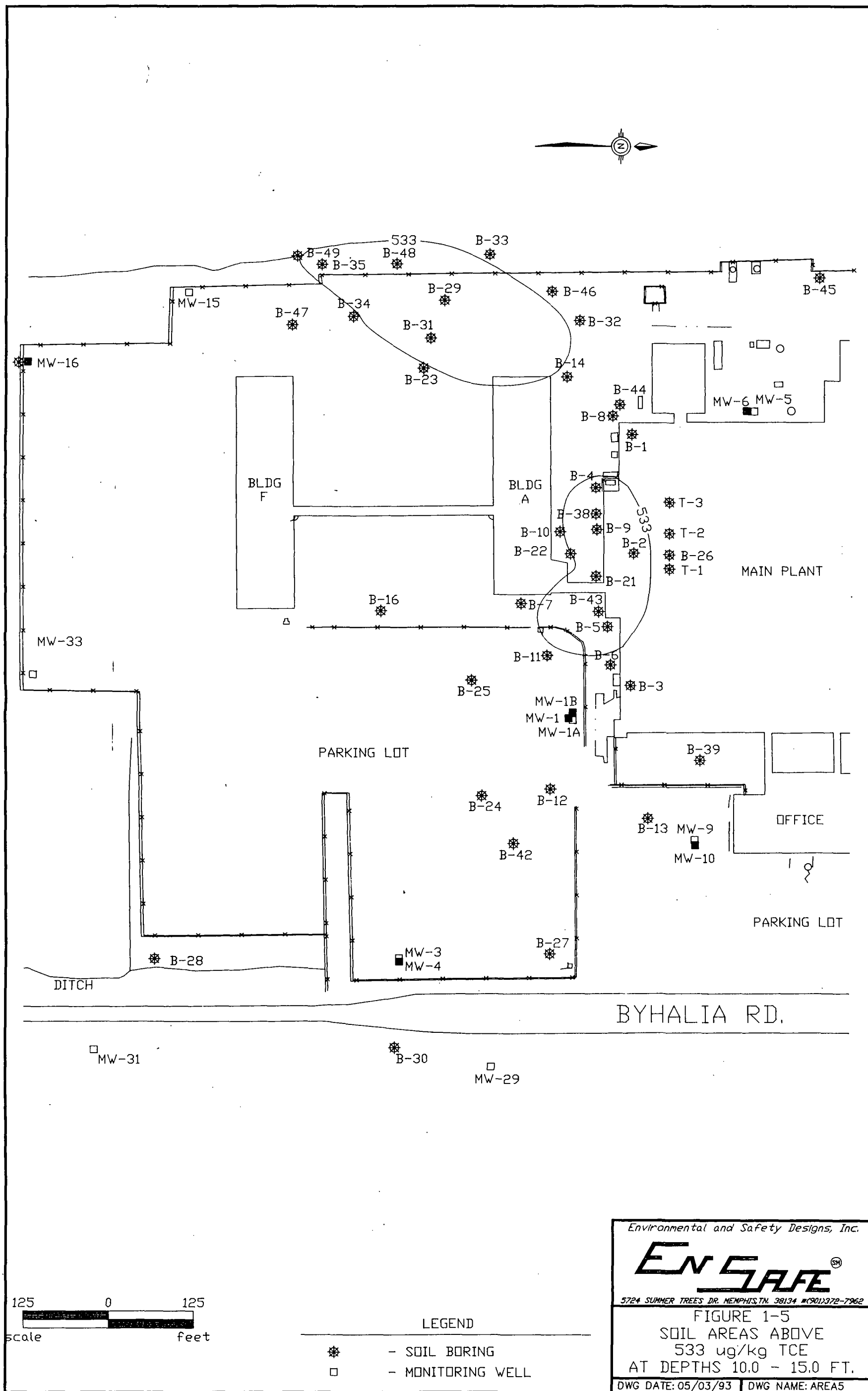
Upon completion of the Collierville Site RI, 37 groundwater monitoring wells (identified generally in this document as MWs) were present at the site. Concentrations of chlorinated hydrocarbons consisting primarily of TCE and *cis* and *trans* isomers of 1,2-dichloroethene (DCE) were found in samples collected from most of the monitoring wells screened in the upper aquifer. DCE and vinyl chloride are natural degradation products of TCE. 1,2-dichloroethane (DCA) and tetrachloroethylene (PCE) were also found during groundwater sampling; however, neither was identified at a significant frequency. Total chlorinated hydrocarbon (TCH) concentrations in these wells range from  $70 \mu\text{g}/\ell$  at MW-23 to  $19,900 \mu\text{g}/\ell$  at MW-19 during the last RI sampling period in February 1991.

Elevated levels of two metals, lead and zinc were indicated in site shallow groundwater samples. In shallow soils, lead values range from 7 to 15 mg/kg, and tend to decrease with depth in virtually all site soils, except at the former lagoon area.









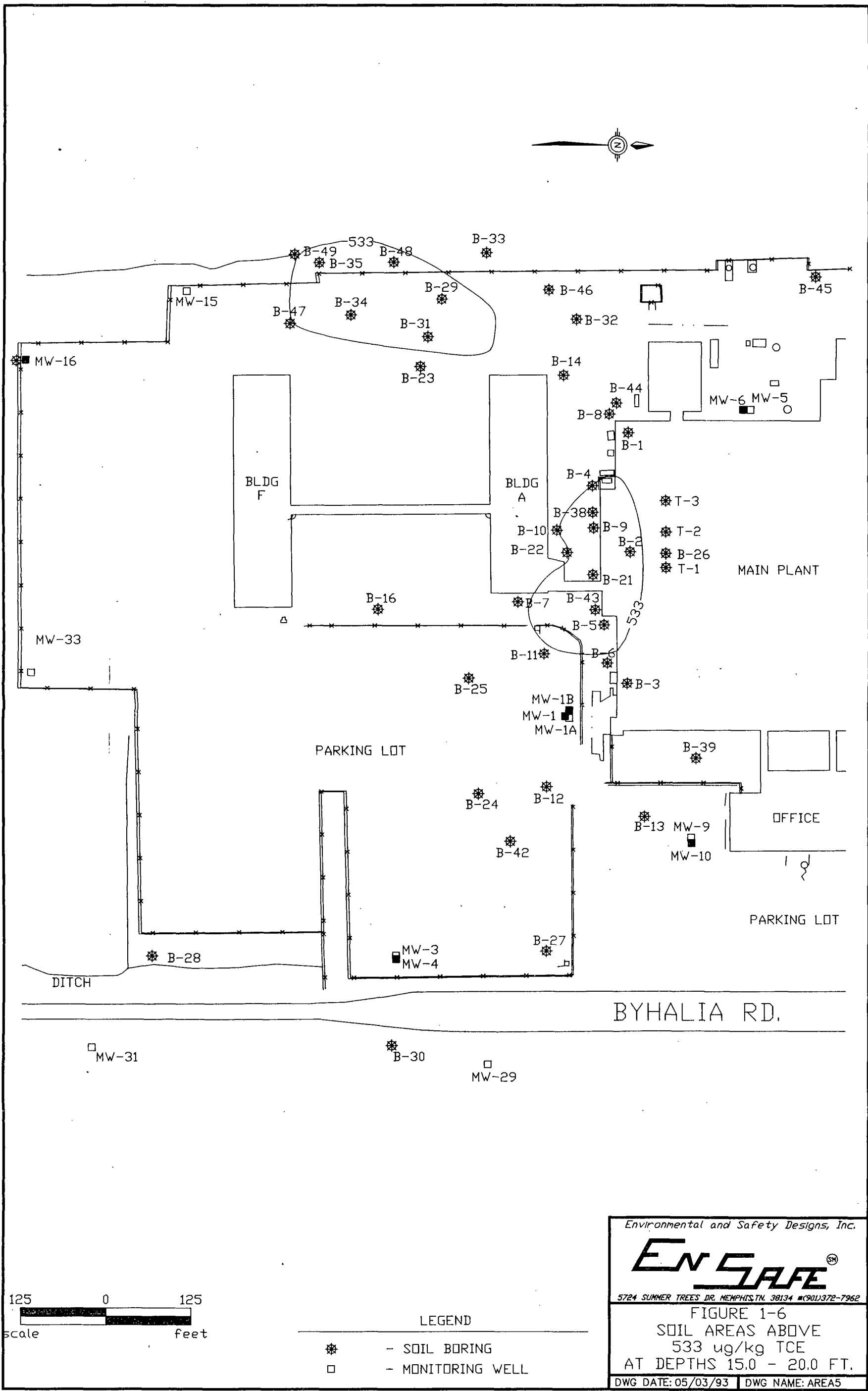
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FIGURE 1-5  
SOIL AREAS ABOVE  
533 ug/kg TCE  
AT DEPTHS 10.0 - 15.0 FT.

DWG DATE: 05/03/93 | DWG NAME: AREA5



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FIGURE 1-6  
SOIL AREAS ABOVE  
533 ug/kg TCE  
AT DEPTHS 15.0 - 20.0 FT.

DWG DATE: 05/03/93 | DWG NAME: AREA5

The former lagoon area may serve as a source of zinc due to the use of zinc phosphate on the site and the discharge of zinc phosphate sludges to the lagoon. However the closure of the lagoon in 1980 appears to have removed these sludges and residual soils concentrations are not higher than site soils in general. Otherwise, no pattern of metals contamination or a source area has been defined.

#### ***Contaminant Distribution, Fate and Transport***

The three documented sources of chlorinated hydrocarbon contamination at the Collierville Site are described above. Residual contaminants from these source areas are still present in specific areas. Furthermore, TCE and its degradation products have been identified in groundwater. Results of soil and groundwater analyses, and soil gas screening data confirm that the two spill areas and the former lagoon area are sources of contamination in site soils and groundwater.

The mechanics for migration of TCE from the source areas to the aquifers depend on solvent-specific characteristics, site-specific geology and hydrogeology. With respect to solvent characteristics, TCE has been characterized as an immiscible fluid with a density greater than that of water, and is classified as a dense non-aqueous-phase liquid (DNAPL) [Ram, et al. 1990].

#### ***Vadose Zone Migration***

Soil boring data indicate that TCE is migrating through the vadose zone. Residual solvent remains adsorbed within the pore space of the soil particles as TCE migrates through the soil. The total volume of fluid released may be stored in this "residual saturation" phase in the vadose zone unless the soil retention capacity has been reached. The actual distance of downward migration of the fluid phase becomes dependent upon the quantity of material released, the soil retention capacity and the thickness of the vadose zone. Pure-phase TCE was not encountered during the investigation, implying that soil retention capacities are not exceeded on the site.

Further migration of TCE from soils occurs as vapor-phase diffusion through soil pores and as migration in the dissolved aqueous phase. TCE vapors have a density greater than air and transport to the shallow aquifer may be enhanced by density-induced advection in the gas phase [Ram, et al. 1990]. At the Collierville Site, TCE appears to be reaching groundwater in the

dissolved aqueous phase from the infiltration and percolation of rainwater through the soils, and through diffusion in the vapor phase.

### ***Shallow Aquifer***

Upon reaching groundwater, the further movement of TCE in the shallow aquifer correlates closely with the structure of the underlying aquitard. Subsurface geological investigations at the Collierville Site have tentatively identified a "structural high" in the Jackson Clay near the former lagoon. The potentiometric surface map of the shallow aquifer reveals that groundwater in the shallow aquifer moves radially from this subsurface feature. The Jackson formation grades from this "high" to the south toward Nonconnah Creek, to the southeast towards Byhalia Road, and generally to the west, along the western extent of the Carrier property. There is some evidence of a slight grade to the north as well, in the vicinity of the town wells and further north.

Advective transport of contaminants in the aqueous phase, from source areas around the main plant and the former lagoon, follow natural shallow groundwater flow directions at the site. There is evidence that groundwater flows only intermittently in the upper aquifer. The intermittent flow is substantiated by the poor recharge to MW-1A, MW-9, MW-11, MW-15, MW-25, and MW-43. Significant amounts of groundwater may be present in localized depressions with very little lateral movement except during high recharge periods. However, around contaminant source areas this movement is generally to the southeast, along the top of the Jackson Formation.

The stratigraphic investigation clearly indicates that shallow groundwater movement to the south and east will eventually migrate to an area in which the Memphis Sand aquifer and the shallow aquifer unit are hydraulically connected.

### ***Memphis Sand Aquifer***

Flow direction in the Memphis Sand is to the northwest, as seen from potentiometric measurements made during periods when the town wells were not pumping. TCE contamination has been identified in the Memphis Sand in the southeast portion of the site (MW-1, MW-1B, and MW-4) and the northwest portion at the municipal wells.

The density of TCE solubilized in water is not likely to be sufficient to cause sinking of the plume [Schwille, 1988]. Therefore, movement of the contaminants to the well field will more directly depend upon the pumping rates of the city well system and the resulting drawdown effects on the Memphis Sand aquifer.

### **3.0 PROJECT DESCRIPTION**

#### **3.1 SOW Task I: Project Planning**

Two data quality objective meetings were held between Carrier and USEPA for the purpose of outlining the objectives and activities of remedial design. These meetings resulted in a consensus to perform the soil and groundwater tasks described in this section.

#### **3.2 SOW Task II: Remedial Design**

Remedial Design tasks will be performed according to criteria outlined in Task II of the Statement of Work (SOW). Task II field work includes soil-vapor extraction treatability work at the MPA, groundwater monitoring work downgradient of the city wells, and confirmatory sampling at the NRS. Field work will be followed by preliminary design. Preliminary designed will be followed by prefinal/final design.

##### ***Soil Field and Preliminary Design Tasks***

Soil field tasks are included within the Soil Vapor Extraction (SVE) treatability study (Appendix A) for this project. A brief soil field activity outline includes:

- NRS Confirmatory Boring Program
- MPA SVE Test Wells and Probes Installation
- MPA SVE Parameter Evaluation Testing
- Pneumatic Characteristic Monitoring and Analysis
- Soil Gas Sampling and Analysis

##### ***Groundwater Field and Preliminary Design Tasks***

Groundwater field and design tasks are detailed in Appendix B:

- Increase operating capacity at Collierville Water Plant 2 groundwater extraction system from its current rate (average 500 gpm) to a minimum rate of 750 gpm
- Implement and design groundwater monitoring program including the installation of a downgradient well to verify containment by the existing city well system
- Assess potential actions triggered by monitoring results

### ***Detailed Design Tasks***

Preliminary MPA SVE design will include criteria for spacing of SVE wells. Preliminary design will not, however, include specific SVE well locations. SVE well locations will be determined after preliminary MPA SVE design is submitted to and approved by EPA.

Once the SVE locations have been determined and installed, detailed design of vacuum extraction and air emission controls (as needed) will be performed.

As needed to assure containment of the plume and restoration of the Memphis Sand, actions selected as a result of preliminary groundwater monitoring data will be detailed.

### **3.3 Deliverables**

RD/RA work plans and reports must be approved by the USEPA, as required by the Unilateral Administrative Order (UAO) and SOW. Copies of the initial draft, revisions, and final approved documents will be submitted to the USEPA along with two copies to the TDEC.

### ***Remedial Design Field Activities Reports***

Separate reports summarizing RD results and analysis for soil and groundwater will be issued following completion of RD field activities. The soils report will include soil treatability data and analysis and estimated SVE well spacings and locations. The groundwater report will include monitoring data and assess the need for changes to the existing groundwater remediation system.

### ***Preliminary Design Report***

Separate preliminary design reports for soil and groundwater remediation will be prepared following completion of remedial design field activities report. Each report will include available design criteria, preliminary hardware plans and specifications, permitting plans and requirements, and a draft construction schedule.

### ***Prefinal/Final Design Reports***

Prefinal/final design reports will include complete design criteria, hardware plans and specifications, permit applications, a final construction schedule, and construction, operation and



maintenance cost estimates. A performance standards verification plan will be appended to this report.

### ***Status Reports***

Status reports will be submitted to USEPA Region IV per a schedule approved by the RPM and Carrier. Status reports will detail all significant site or offsite activities whether they are administrative or operational, including the progress of those activities. All corrective measures, site problems, public relations, or any significant event that occurs with regards to the Carrier Collierville Site will be documented in the status report.

In addition, any data collected during the previous month, analytical results, etc. will be summarized in the status report. A photocopy of the status report will remain on file at EnSafe's Memphis office.

### **3.4 Sequencing of Remedial Design Activities**

Design activities are sequenced to achieve design goals within the time stipulated by the USEPA. Remedial design activities at the Carrier Collierville project began with the installation and operation of the soil-vapor extraction system at the North Remediation Site and the air stripper groundwater treatment system at the Town of Collierville Water Plant 2. A field trailer and decontamination pad were also installed for use during periodic sampling and remedial activities.

Additional design field activities include installation of SVE treatability study wells and probes and a monitoring well cluster screened in the Memphis Sand and downgradient from Water Plant 2. When installation operations are complete, SVE parameter testing and periodic downgradient well groundwater sampling will begin. Pending SVE test results, additional SVE wells will be installed to complete the SVE system. Groundwater results will be reviewed to assess extraction system performance.

The results from design activities will be logged, reviewed, and presented in the Remedial Design Report.

After the current status of the contaminant levels has been determined and the results of treatability studies have been evaluated, preliminary and final remedial design will be performed

and remedial activities will begin in accordance with the SOW. After active remedial efforts have been implemented, the project emphasis will shift to attendant monitoring and maintenance.

## **4.0 PROJECT MANAGEMENT PLAN**

### **4.1 Schedule**

Figure 4-1 presents the schedule for management of design and completion of each required activity and submission of each deliverable required by the UAO and the SOW. The schedule includes timing, initiation, and completion information for each critical path milestone.

### **4.2 Organization**

Figure 4-2 shows the organizational structure of the project management team.

### **4.3 Data Management Plan**

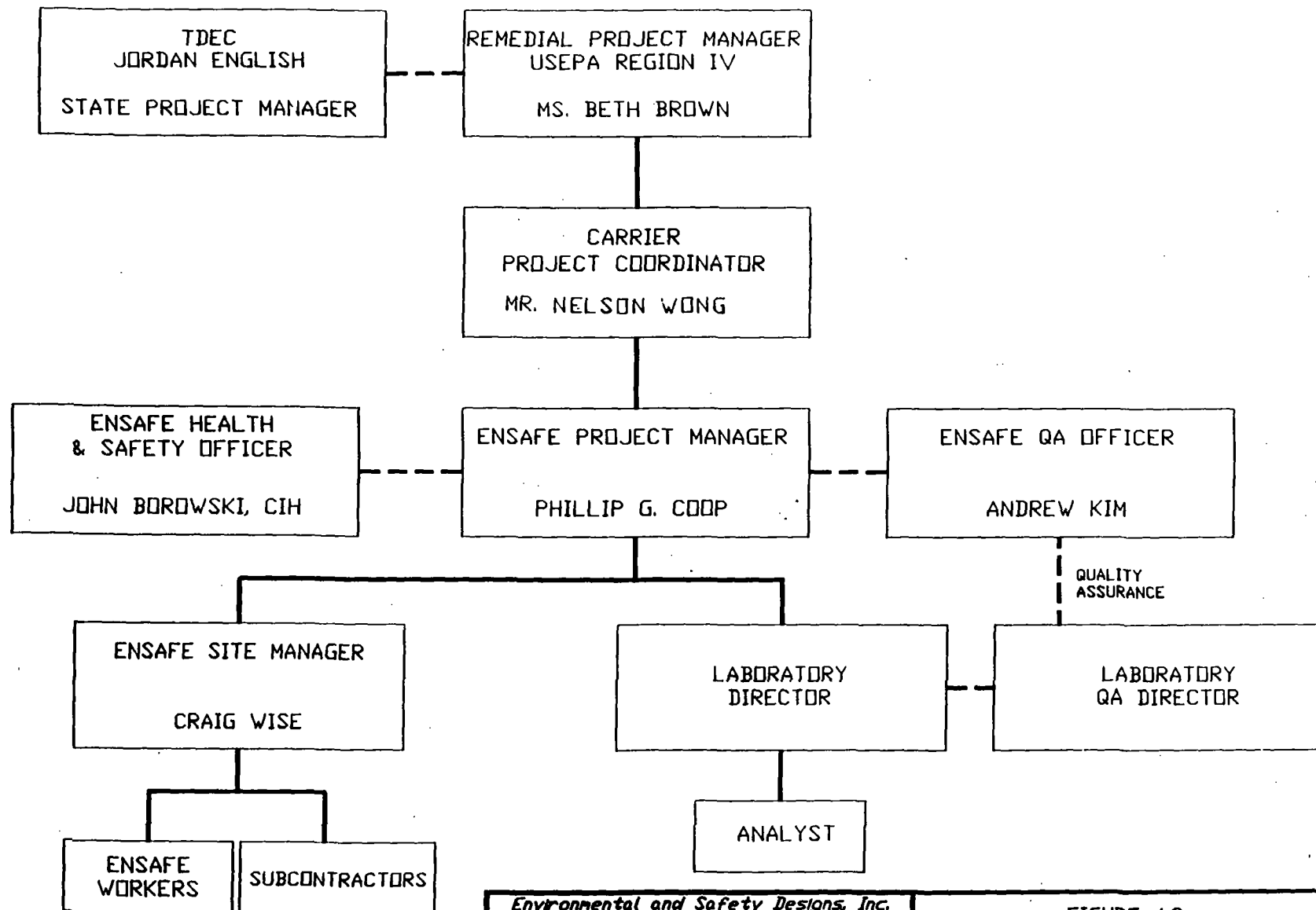
Data management includes procedures for tracking, sorting, and retrieving all data generated during this project. All data requirements, formats, and backup plans will be conducted in accordance with procedural protocols for environmental monitoring and measurement data as established in:

- *Standard Operating Procedures and Quality Assurance Manual*, Environmental Compliance Branch, US EPA Region IV-ESD, Athens, Georgia, February 1991. (This document will be referred as EPA SOP/QAM in this report.)
- *USEPA Locational Data Policy*, USEPA Officer of Information Management (OIRM)
- USGS Soil Classification
- State, city, and county well installation reporting guidelines

Specific protocols are detailed in Appendix D, the Quality Assurance Project Plan, of this report.

### **4.4 Status Reports**

Provisions for status reports are as discussed in Section 3.3 — *Deliverables*.



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FIGURE 4.2  
PROJECT ORGANIZATION  
COLLIERVILLE SITE  
REMEDIAL DESIGN WORK PLAN

DWG DATE: 05/03/93 | DWG NAME: CARLORG

#### **4.5 Meetings and Presentations**

Meetings and presentations will be scheduled as needed. Representatives of EnSafe, Carrier, USEPA, and TDEC will be invited to each meeting.

#### **4.6 Community Relations Support Activities**

Community relations will be managed primarily by USEPA. EnSafe and Carrier will assist in preparing and disseminating information regarding RD work as directed by the USEPA.



**APPENDIX A**

**SOILS TREATABILITY STUDY WORK PLAN**

## **Table of Contents**

1.0	INTRODUCTION .....	A-1
2.0	OBJECTIVES .....	A-2
3.0	SOILS TREATABILITY STUDY PROCEDURE .....	A-3
3.1	Remedy Pre-Screening .....	A-3
3.2	Drilling and Preliminary Sampling Activities .....	A-5
3.3	MPA Parameter Evaluation Testing .....	A-9
4.0	TREATABILITY STUDY DATA INTERPRETATION .....	A-12
4.1	Distribution and Extent of TCE Contamination .....	A-12
4.2	Air Permeability and Zone of Influence .....	A-12
4.3	Contaminant Loading Rates .....	A-14
5.0	SVE SYSTEM DESIGN APPROACH .....	A-15
6.0	SVE SYSTEM OPERATION AND DESIGN .....	A-16
7.0	SVE COMPLETION AND TERMINATION .....	A-17
8.0	SVE TREATABILITY RESIDUALS MANAGEMENT .....	A-18

## **List of Figures**

Figure 3-1	SVE Well and Probe Locations .....	A-8
------------	------------------------------------	-----



## **1.0 INTRODUCTION**

Vadose zone soils in some areas at this site contain TCE which, at its current concentration, may be contributing to unacceptable levels of on-going contamination of the Memphis Sand aquifer. As stated in the ROD, soils within these source areas will be remediated using SVE. This work plan will address treatability work at the Main Plant Area and confirmatory soil sampling at the North Remediation Site near the former lagoon/sludge area. The following sections detail treatability objectives, procedures and data interpretation, and SVE system design approach.

## 2.0 OBJECTIVES

The following objectives are vital to the design and operation of the MPA SVE system:

- Confirm the status of TCE contaminated soils as described in the RI/FS.
- Assess post-treatability study TCE soil concentrations at the NRS.
- Obtain SVE design parameters such as soil permeability and pressure thresholds.
- Gather data needed to evaluate treatment options for air emissions.
- Gather data needed to estimate the time required to achieve soil cleanup criteria.
- Design a sampling and monitoring plan evaluating the effectiveness of the SVE system.

The level of quality of analytical and treatability results required for design will be governed by the data quality objectives listed below.

### Data Quality Objectives:

- Use measurement and analytical methods capable of detecting or indicating confirmed site constituents at levels equal to or below site soil cleanup criteria.
- Produce sampling/analysis data which can be reproduced so that it may be compared with historical and future sampling data.
- Obtain pilot test data of quality sufficient to design a full-scale SVE system, including extraction well placement and contaminant loading rates. Data must be representative of all areas which must be addressed and of sufficient accuracy to yield a sound design.

### Methods of Obtaining Remedial Design and Data Quality Objectives:

- Set criteria for sampling event completeness, precision, accuracy, and minimum detection levels.
- Use calibrated equipment capable of providing accurate design parameter data.
- Locate extraction wells and monitoring probes in areas of the spill area representative of soils to be addressed by the full-scale SVE system.
- Conduct the treatability study as outlined in USEPA's *Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction*.

Quality assurance objectives and methodologies for all sampling required during the SVE pilot study are presented in Appendix D, Section 4.

### **3.0 SOILS TREATABILITY STUDY PROCEDURE**

The soils treatability study at this site began during the RI/FS when remedy pre-screening was performed for potential remedial technologies. The NRS treatability work was performed to verify the selection of SVE over alternative technologies, and as such, was not sufficient to complete SVE for soils at the MPA. This section summarizes historical pre-screening activities, details future drilling activities, and describes specific activities needed to complete site treatability work.

#### **3.1 Remedy Pre-Screening**

Pre-screening of physical and chemical soil and contaminant properties is necessary to evaluate a technology's potential to achieve remedial goals. During RD project planning (Task I) previous site investigations, SVE studies and other site-specific physicochemical properties were researched to assess this potential for SVE.

Physical and chemical soil properties which may affect SVE include air permeability, moisture content, organic content, soil temperature, and the target contaminant's vapor pressure. These factors and their effect on SVE are discussed below.

#### ***North Remediation Site SVE Treatability Work***

SVE treatability work was performed at the NRS during Winter and Spring, 1992. A treatability work summary of the procedures and results is provided as Attachment A to this Appendix.

Testing included the operation of a four shallow well/five deep well soil vapor extraction system utilizing a 225-cfm regenerative blower. Emission sampling results showed removal of approximately 7000 pounds of TCE over three months of operation. Results also indicated that approximately 90 percent of this amount was removed in the first 30 days.

Section 3.2.1 describes the confirmatory soil sampling to be performed as part of this project to evaluate the removal efficiency of TCE from the soil.

#### ***Subsurface Conditions***

Boring logs from both the NRS and the MPA show vadose soils in two distinct layers— a shallow silty zone and a deeper sandy zone. As was seen during NRS treatability work, the low

permeability of the shallow zone can impede the effectiveness of SVE; however, high vacuum pumps and/or horizontal trenching may be used to improve the efficiency of a shallow SVE system. The high permeability of the deeper sandy soils makes the deep zone a good candidate for SVE.

Shallow soils also contain extensive utility trenching in some areas near the MPA. These trenches can provide rapid migration pathways in otherwise impermeable soils. Therefore, site utility maps will be studied prior to placement of SVE wells to assess their potential influence on pilot testing.

#### ***Moisture Content***

The moisture content of vadose soils at this site ranges 10 to 20 percent. This range is not so moist that it will greatly inhibit air flow, nor is it so dry that TCE will be unusually adsorbed to soil particles.

#### ***Organic Content***

Due to preferential adsorption, high organic carbon content (total humic and fulvic acid content greater than ½ % of total soil weight) in soils can prevent SVE from achieving soil cleanup criteria in a timely manner. However, laboratory testing indicates the fraction of organic carbon in soils at this site to be approximately 0.0013. This value falls within the normal range for these soil types, and unusually high adsorption to organic content is not expected.

#### ***Temperature***

Soil temperatures are sensitive to the ambient climate. Because the Memphis area is not prone to extended periods of extreme cold, soil temperatures at this site are not expected to drop to levels prohibitive of SVE.

#### ***Chemical Parameters***

The primary chemical parameter affecting SVE performance is the contaminant's volatility. The high vapor pressure of TCE makes the compound readily volatile under normal atmospheric conditions. Therefore, SVE should effectively remove TCE from the soil.

### ***Pre-Screening Conclusions***

The above soil and chemical characteristics indicate that SVE is a suitable remedial alternative for this site. The following activities will be performed during this treatability study to confirm pre-screening conclusions.

- A confirmatory soil boring and sampling program will be performed at the NRS system. Sample results will be assessed to verify whether a nominal concentration level of 533  $\mu\text{g/kg}$  TCE concentration in soils can be achieved through use of SVE.
- Moisture and organic content samples will be collected during SVE well and probe installation.

### **3.2 Drilling and Preliminary Sampling Activities**

Drilling and preliminary sampling activities during this investigation include all preliminary sampling, boring, and well and probe installation activities required to complete both the MPA SVE treatability study and the NRS confirmatory soil sampling program.

#### **3.2.1 NRS Confirmatory Sampling**

Prior to performing soil sampling, preliminary soil gas and soil sampling will be performed to study diffusion within the vadose zone. Soil gas sampling will proceed as follows:

- The NRS vacuum inlet manifold will be sampled and analyzed for TCE. Sample spikes will be sent with emission samples to verify laboratory accuracy.
- The NRS SVE system will be shut off and remain inactive for approximately 30 days.
- The system will be reactivated and inlet concentration samples will again be sampled.

After soil gas sampling is completed, three shallow and three deep soil borings will be installed to collect soil samples for laboratory screening analysis of VOCs by the co-distillation method used and approved during the RI (Woodsen-Tenant Method). Results will be used to assess:

- whether SVE has reduced soil TCE concentrations at the NRS below the cleanup criteria of 533  $\mu\text{g/kg}$  or
- whether SVE is capable of meeting cleanup goals at the MPA.

### **Boring Installation and Sampling**

Borings will be advanced using 4.25" ID hollow-stem augers with split spoon samples collected continuously to assess stratigraphy. Soil samples for laboratory analysis will be collected during boring installation at 10-foot intervals beginning 5 feet below ground surface.

Two samples from each spoon will be submitted for laboratory screening VOC analysis and organic carbon content (specifically fulvic and humic acids). Each sample will be placed in glass containers with teflon-lined septum lids. Samples not intended for lab analysis will be extracted and screened for relative VOC concentrations using a flame or photoionization detector.

Drilling equipment will be decontaminated between drilling of each boring using the decontamination procedures listed below. First perform an initial inspection of over-borehole equipment for residual rust, soils, or other material, and condition of seals and gaskets, equipment will be positioned on the onsite decontamination pad. If the surfaces of downhole equipment are painted, badly rusted or coated with materials that are difficult to remove using a steam cleaning/ wire brush procedure, sandblasting must be employed.

1. First, position equipment over the decontamination pad onsite.
2. Equipment will be washed thoroughly with a steam cleaner and wire brushed as necessary to remove all rust, soils, and other material.
3. Equipment will be rinsed with deionized/organic-free water.

All down-hole and other stainless steel sampling equipment and the split-spoon samplers will be decontaminated between samples using the decontamination procedures listed below.

Down to clay  
grabs for VOCs

1. Equipment will be washed thoroughly with a steam cleaner and/or pressure washer and laboratory detergent/hot water, using a brush if necessary, to remove any particulate matter or surface film.
2. Equipment will be pressure-rinsed with tap water, deionized/organic-free water, then twice with pesticide-grade isopropyl alcohol, then again with deionized/organic-free water, and allow to dry as long as possible.
3. Sampling equipment will be wrapped in aluminum foil (shiny side out) until ready for use (non-sampling equipment may be wrapped in plastic to avoid contamination).
4. Field personnel will don a new pair of disposable nitrile gloves before handling sampling equipment. Gloves will be discarded between individual sample collection to prevent cross-contamination.

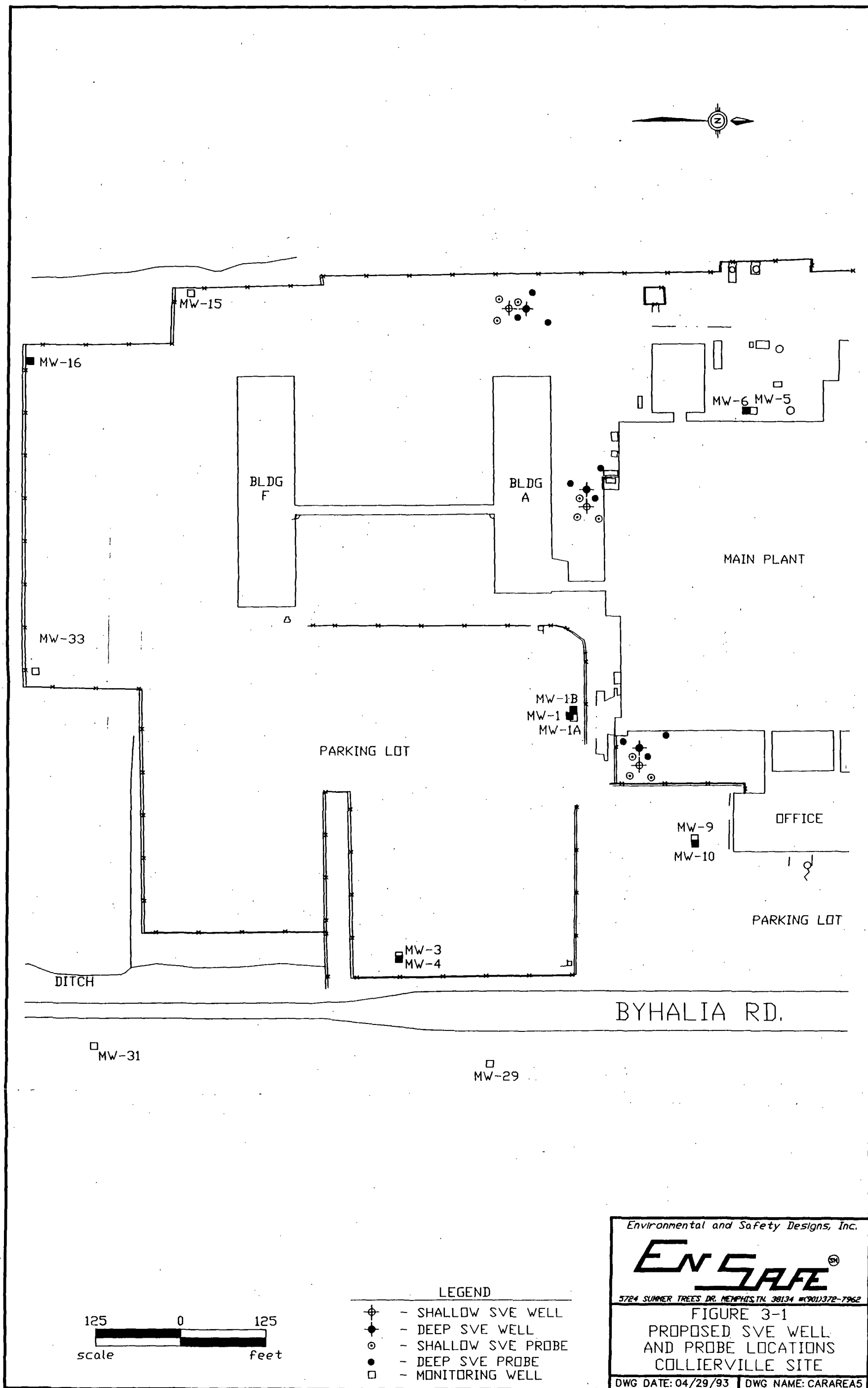
### **3.2.2 MPA Drilling Activities**

The MPA SVE treatability test requires the installation of at least three shallow and three deep SVE wells. Three vapor probes per vapor extraction well will be installed to monitor pressures during treatability testing. Proposed vapor extraction well and probe locations are presented in Figure 3-1. To assess the influence at larger lateral distances, vapor probes located at adjacent test clusters will be used.

Soil boring or extraction well installation in the vicinity of boring 27 will not be conducted initially. Extraction wells may later be installed in this area per the criteria stated in Section 5.

#### ***Boring Installation, Soil Sampling, and Decontamination Procedures***

These procedures will be performed as described in Section 3.2.1. Well casing and screen will be decontaminated as with sampling equipment after sanding to remove printing inks.





### ***Well Installation***

Borings will be converted to wells using 2" ID Schedule 40 PVC Pipe. The screen intervals for the wells will be determined in the field based upon FID/PID results and soil strata. In general, screens will be set at depths of higher VOC concentration and more permeable strata. Shallow screens will be set within the shallow silty soils, while deep wells will be set in the deeper sandy soils.

A medium to coarse-grained filter pack will be installed around the screen interval with a 1 to 2-foot bentonite seal on top of the sand pack. The bentonite seal will be allowed to hydrate at least 24 hours before cement/bentonite grout is used to fill the remaining annular space.

### ***Probe Installation***

If possible, soil vapor probes will be advanced using a hydraulically driven 1" steel pipe. If a hydraulic rig cannot install probes to their required depth, probes will be installed as described in well installation.

If driven probes cannot be implemented, soil vapor probes will be converted from borings using 1/2-inch ID Schedule 40 PVC screen and riser pipe. A medium to coarse-grained filter pack will be installed around the screen interval (6") with a 1-2' bentonite seal on the bottom and top of the sand pack. The remaining annulus above the bentonite seal will be filled with a cement/bentonite grout.

### **3.3 MPA Parameter Evaluation Testing**

At least three SVE Parameter Evaluation Tests will be conducted to evaluate the physical and chemical characteristics of the site soils. PETs are performed by using a blower to extract soil vapor through a solitary SVE well while monitoring pressure changes in multiple, close-by vapor probes.

A listing of the equipment necessary to conduct the PETs is shown below:

- SVE vacuum pump system, consisting of an Axial Hi-Volume, Low-Pressure Turbo-Vane Blower (ATVB) for the deep SVE wells which shall provide approximately 800 scfm at

1.5 inches H<sub>2</sub>O. A Transverse Regenerative, Low-Volume, Hi-Pressure Blower (RHPB) will be utilized for the shallow SVE wells and shall provide up to 60 scfm at 110 inches H<sub>2</sub>O.

- Granular Activated Carbon adsorbers, 55 gallon capacity.
- Vacuum gauges/transducers to measure influence in the SVE probe wells.
- Vapor probes to detect vacuum influence in the subsurface.
- Mobile laboratory to analyze for chlorinated hydrocarbons.

PET results will be used to assess:

- Emission loading rates needed for planning operation and sizing control equipment, and well spacings for the full scale SVE system.
- Subsurface pneumatics needed for estimating SVE well spacing. If pneumatics vary greatly from location to location and well spacings cannot be estimated with confidence, additional PETs will be performed until spacings can be adequately assessed.

To assess variability in soil type and VOC distribution across the site, PETs will be conducted at three separate locations, with one deep and one shallow test at each location. The specific vacuum pump system and air flow rates utilized for each test will depend upon the physical characteristics of the soil and the installation details of the test well.

Each well will be tested at two or more operating vacuums and air flow rates to allow collection of physical data required for the calibration and verification of air flow models. Test durations will vary, depending on the relative VOC concentrations and the physical characteristics of the soils in the vicinity of the well. At a minimum, tests will be conducted until a steady well air flow rate and steady vacuum pressures have been achieved at the test well and vapor probes (in the vicinity of the test well).

### ***PET Physical Parameters***

Physical data collected during each SVE test will include vacuum pressure measurements at the test well and surrounding vapor probes, and well air flow rate measurements. Pressure decline measurements within extraction wells and probes will be obtained using pressure transducers. Pressure responses from the transducers will be recorded at periodic intervals. Additionally, flow meters will be used to monitor air flow rates within the extraction well. At the conclusion of each test, the SVE data will be used to calculate soil permeabilities and maximum pressure decline at each probe.

### ***PET Chemical Parameters***

The primary chemical parameter consists of identifying and quantifying the VOCs which are drawn into the SVE test system from soils in the vicinity of the test well. Vapor samples will be collected from the effluent vapor sampling port at the start, during, and at the end of each test and from vapor probes at the start and end of each test. Samples will be collected by the soil gas subcontractor in 50 ml evacuated glass cylinders. These additional samples will be analyzed in the mobile laboratory located on site according to modified EPA Method 601/602 using an electron capture detector (ECD) equipped with a gas chromatograph (GC) to analyze for chlorinated hydrocarbons.

#### 4.0 TREATABILITY STUDY DATA INTERPRETATION

Treatability study data will be interpreted to evaluate the distribution of TCE contamination in areas tested, assess air permeabilities in the vadose zone, estimate contaminant loading rates, and design a full-scale SVE system capable of achieving cleanup criteria set forth by the ROD in a cost effective time.

##### 4.1 Distribution and Extent of TCE Contamination

Soil and soil gas samples collected during the pilot study will help define areas of higher and lower relative TCE concentration. During full-scale SVE design and operation, this information will be used to target areas of higher concentration with extra extraction wells, higher flow rates, or higher vacuum levels.

##### 4.2 Air Permeability and Zone of Influence

The pilot study will produce data necessary for estimating the radius of vacuum influence of an individual extraction well. This estimate may be affected by variations of the soil properties of the vented zone, the depth of the extraction well screen, and the presence of any impermeable boundaries.

Pressure decline data and air flow and vacuum conditions will be plotted for each test. The slope of the pressure decline for each monitoring probe will be used to estimate the soil permeability to vapor flow by the method discussed in Johnson et al. (1990). The predicted change in subsurface pressure distribution is determined by:

$$P_1 = \frac{Q}{4\pi m \left( \frac{k}{\mu} \right)} \int_0^\infty \frac{r^2 \epsilon \mu}{4ktP_{atm}} \frac{e^{-x}}{x} dx$$

For  $(r^2 \pi \mu / 4kP_{atm} t) > 0.1$ , the above equation can be approximated by:

$$P_1 = \frac{Q}{4\pi m \left(\frac{k}{\mu}\right)} [-0.5772 - \ln(r^2 \epsilon \frac{\mu}{4} k P_{atm}) + \ln(t)]$$

Where:

- $P_1$  = gauge pressure measured at distance  $r$  and time  $t$
- $m$  = stratum thickness
- $r$  = radial distance from extraction well
- $k$  = soil permeability to air flow
- $\mu$  = viscosity of air ( $= 1.8 \times 10^{-4}$  g/cm-s)
- $\epsilon$  = air-filled soil void fraction
- $t$  = time
- $Q$  = volumetric vapor flow rate from extraction well
- $P_{atm}$  = ambient atmospheric pressure ( $= 1.0$  atm  $= 1.013 \times 10^6$  g/cm-s<sup>2</sup>)

The above equation predicts a linear relationship between  $P_1$  and  $\ln(t)$  with slope  $A$  and y-intercept.

Factors  $A$  and  $B$  can be expressed by:

$$A = \frac{Q}{4\pi m \left(\frac{k}{\mu}\right)}$$

$$B = \frac{Q}{4\pi m \left(\frac{k}{\mu}\right)} [-0.5772 - \ln(r^2 \epsilon \frac{\mu}{4} k P_{atm})]$$

Therefore, the permeability to air flow can be calculated from the vapor extraction test data by two methods.

(if Q and m are known)

$$k = \frac{Q\mu}{4A\pi m}$$

(if Q or m are not known)

$$k = \frac{r^2 \epsilon \mu}{4P_{atm}} \exp\left(\frac{B}{A} + 0.5772\right)$$

#### 4.3 Contaminant Loading Rates

Emissions from the SVE pilot study will be monitored and sampled to predict TCE loading rates produced during full-scale SVE remediation. This information is necessary to size and operate the system and to evaluate treatment options for air emissions.

As described in the Feasibility Study, the maximum amount of TCE allowed to be discharged to the air is 3 lbs/hr, 15 lbs/day, 10 tons per year (OSWER Directive 9355.0-28). Based on available site data, the full-scale SVE system will likely exceed the allowable emissions standard and will require off-gas treatment and reduced flow rates during early SVE treatment periods. Secondary emission control will also be necessary during the SVE pilot study.

## **5.0 SVE SYSTEM DESIGN APPROACH**

With spacings based on PET results, additional deep wells will be installed beginning in a hexagonal pattern around SVE wells used during the PETs. Wells will continue to be installed in a triangular spacing pattern until soil samples collected during installation indicate that the zone of capture of the SVE system will be capable of achieving remedial goals.

Because pre-screening results indicate shallow SVE well spacings may be less than half of the deep well spacing, SVE may require four times more vertical shallow wells than deep wells. Instead, shallow SVE design may require trenching or horizontal boring and lateral extraction SVE pipes to be cost effective. Design of the shallow system, however, will still be based on PET pneumatic results and will attempt to target source areas ( $\text{TCE} > 533 \mu\text{g/kg}$ ). In any case, shallow extraction screened intervals will be installed while taking care to avoid pulling vapor from the more permeable deep zone or ground surface, which would result in preferential flow patterns, and render part of the interval ineffective.

## **6.0 SVE SYSTEM OPERATION AND DESIGN**

The type and size of vacuum, the number and spacing of SVE wells, the time period of operation, and the physical characteristics of the remediation zone are the primary factors affecting system design. Also, emission rates during the SVE treatability study will determine the type and size of secondary emission controls needed for the full scale SVE system. All three factors will be balanced based on SVE treatability results to design a cost effective system capable of meeting remedial goals specified in the ROD.

Blower size and well spacings are interrelated. Larger blowers can allow for greater well spacings, therefore reducing the number of wells required to cover a given area. However, larger zones of influence can also take longer to generate, and contaminant travel distances increase, thereby increasing the period of operation. Multiple blower/well spacing scenarios will therefore be studied and compared before selecting a final design.

Physical soil characteristics can affect the target areas of the SVE system. The difference in permeabilities in the two zones is likely to be sufficiently large to require separate vacuum sources and piping manifolds. The shallow, silty-clay soils at this site may require a greater number of wells and higher vacuum stress to remediate than the deeper, sandy soils. Further extraction from the shallow soils may be limited by diffusion effects, therefore, system design may only target the highest areas of contamination in the shallow soils, while attempting to cover the entire deep contaminated zone. In this manner, remedial goals may be accomplished without having to install extraction wells throughout the entire shallow zone.



## **7.0 SVE COMPLETION AND TERMINATION**

Emission concentrations, vapor flow rates, and a confirmatory soil sampling program will be used to estimate when the SVE system can be shut off.

When emission rates decline to where the system can operate at maximum flow and all SVE wells may be activated, an emission concentration vs. time curve will be plotted and compared to a similar curve generated for the NRS. This comparison will yield a time at which 533  $\mu\text{g}/\text{kg}$  can be expected to be reached.

When extracted soil gas concentrations indicate that remedial goals have been achieved by comparison with either the NRS or typical removal curves, a confirmatory soil sampling program will be performed.

A program of continued soil gas monitoring will then be initiated to assure that further contaminant diffusion from zones treated during remediation is not occurring. If soil gas concentrations increase to significant levels, the SVE system will be reactivated and operated until soil gas concentrations are again reduced to levels indicative of soil matrix concentrations below 533  $\mu\text{g}/\text{kg}$ .

## **8.0 SVE TREATABILITY RESIDUALS MANAGEMENT**

Residual soil resulting from MPA drilling activities and NRS confirmatory sampling will be placed on an impervious surface and covered with plastic. All soil will ultimately be integrated into the full-scale MPA SVE installation. Liquid residuals collected during treatability testing, and full-scale operation can be collected for periodic transfer to the NRS air stripper. Residual activated carbon will be disposed of at a permitted offsite facility.

**Attachment A**

**Carrier/Collierville  
North Remediation Site  
Soil Vapor Extraction Treatability Work Summary**

## **Table of Contents**

1.0	INTRODUCTION . . . . .	1
2.0	PRELIMINARY SAMPLING . . . . .	2
2.1	System Vacuum Testing . . . . .	2
2.2	Short-term Trials . . . . .	3
2.3	Emission Mass Loading Test . . . . .	5
2.4	Long-term Extraction Trial . . . . .	5
3.0	SAMPLING METHODS AND QA/QC . . . . .	11

## **List of Figures**

Figure 1	Concentration vs Time graph . . . . .	10
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## **List of Tables**

Table 1	Carrier Collierville SVE Data . . . . .	7
Table 2	Spike Results . . . . .	12

## **1.0 INTRODUCTION**

This report presents the status of the treatability work being performed for the North Remediation Site Soil Vapor Extraction System at the Carrier, Collierville site. The goal of this study was to determine the overall effectiveness of SVE and develop preliminary design for SVE at this site. The study included five phases:

1. preliminary sampling
2. system vacuum testing
3. short-term extraction trials
4. emission mass loading test
5. long-term extraction trial

Results to date indicate that SVE is highly effective for treatment of the deeper, sandy vadose zone soils and slightly effective for treatment of the more shallow, silty vadose zone soils.

## **2.0 PRELIMINARY SAMPLING**

Prior to system startup for each SVE test, background pressure levels and trichloroethylene soil gas concentrations were measured for reference in determining total SVE system performance. Pressure and soil gas sampling techniques are described in Section 3 of this attachment. Pressure data fluctuated between negative 1.6 inches water column relative to atmospheric (WCRA) at Recovery Well RW-9 prior to a shallow short-term extraction trial and positive 1.9 WCRA inches at RW-8 prior to the emission mass loading test. Variations in background pressures were assumed to be a result of fluctuations in ambient barometric pressures.

Initial trichloroethylene soil gas concentration levels were measured through field sampling and subsequent laboratory sampling. Field sampling was performed on December 17, 1991. Results of analyses indicated significant levels of TCE present in all samples except vapor probe PZ-3 @ 15' and deep recovery wells RW-3 and RW-5. The low concentrations in RW-3, RW-5, and PZ-3 @ 15' are believed to be a result of insufficient access to the vadose zone due to improper well and/or sample port construction. A maximum concentration of 98 mg/L was encountered in deep recovery well RW-9.

### **2.1 System Vacuum Testing**

Prior to performing extraction trial testing, a static vacuum leak test was performed on the shallow and deep extraction systems. During each vacuum test, all recovery wells were sealed using gate valves located at each wellhead. The shallow test was performed by shutting the gate valve leading from the vacuum blower to the deep system and opening the gate valve leading to the shallow system. The vacuum blower was activated and run until system pressure reached steady state. Upon reaching steady state, the gate valve leading to the shallow system was closed and the vacuum blower was subsequently deactivated. Shallow system piping manifold pressure was monitored to record the rate of pressure dissipation using a digital manometer. Results of the test indicated minimal pressure dissipation throughout the shallow system.

The deep vacuum test was performed in the same manner as the shallow test, with isolation being achieved through closing the gate valve leading from the vacuum blower to the shallow system. Deep vacuum test results indicated a quick decline in pressure following isolation from the vacuum blower. This result indicates that significant in-leakage is occurring in the deep

system piping. Leakage was later confirmed during the extraction trials by observation of significant pressure drops from the vacuum blower inlet to the deep wellheads.

## **2.2 Short-term Trials**

Short extraction trials were performed on both the shallow and deep well systems to estimate air flow rates through the vadose zone and approximate soil vapor capture zones induced by the extraction system. Extraction trials included: (1) preliminary and active pressure readings from sample ports located at each wellhead and piezometer PZ-3, (2) monitoring of total air temperature and flow rates through the emission stack, and (3) selected soil gas sampling during the test runs. Results indicated favorable conditions for the deep recovery system and less favorable conditions for the shallow recovery system.

### **Shallow System**

The shallow system short-term extraction trial was performed on December 31, 1991. The system was tested with recovery well RW-8 open, and all other shallow recovery wells closed (RW-6, RW-7, and RW-9). The gate valve was closed leading from the vacuum blower to the deep well manifold. System startup and shutdown occurred at 11:42, December 31, 1991, and 13:30, December 31, 1991, respectively.

Pressure measurements were taken at each recovery well and piezometer PZ-3. Pressure was read prior to the test, immediately following system startup, and again approximately two hours subsequent to startup.

Flowrate was measured at the system emission stack using a pitot tube. Differential pressure measured by the pitot tube was converted to a flow rate using conversion functions provided by the manufacturer. Approximately two hours subsequent to system startup, flow rates were approximately 38 cubic feet per minute (SCFM) and emission air temperatures exceeded 240 degrees Fahrenheit. Due to the low flowrate and excessive emission air temperature, the test was aborted 107 minutes after startup.

No significant pressure drop occurred at any PZ vapor pressure sampling port location as a result of the shallow extraction trial. Therefore, a relatively small areal extent of significant TCE recovery is expected in the shallow vadose zone soils as a result of short-term soil vapor

extraction. However, with all four shallow recovery wells open during the longer term extraction trial, an increase in the amount of soil gas extraction within the shallow vadose soils can be expected.

### **Deep System**

The deep system short-term extraction test was performed on December 30 to 31, 1991. The deep system was tested with recovery well RW-3 open, all other deep recovery wells closed (RW-1, RW-2, and RW-4), and the gate valve closed leading from the pump to the shallow recovery system. System startup and shutdown occurred at 14:12, December 30, 1991, and 10:15, December 31, 1991, respectively.

Pressure measurements were taken at each recovery well and piezometer PZ-3. Pressure was read prior to the test, immediately following system startup, again at approximately 14:44, 14:57, and 16:10, December 30, and again at 09:35 and 10:00, December 31. Vacuum pressure readings slowly increased at a decreasing rate throughout the test. The last two sets of readings indicated that vacuum pressures were becoming relatively stable; therefore, final soil gas samples were collected, and the extraction trial was terminated.

Flow rate was measured at the system emission stack using a pitot tube. Differential pressure measured by the pitot tube was converted to a flow rate using manufacturer provided conversion functions. Approximately two hours subsequent to system startup, flow rates were approximately 130 cubic feet per minute and emission air temperatures were approximately 140 degrees Fahrenheit. When converted to standard temperature, air flowrate was equal to approximately 200 ACFM. The flowrate and emission air temperature remained at or near these levels throughout the 20 hour test.

As a result of the deep extraction trial, a significant pressure drop occurred at all sampling locations except PZ-3 @ 15'. Therefore, a relatively large areal extent of significant TCE extraction is expected in the deep vadose zone soils as a result of soil-vapor extraction. Moreover, all five shallow recovery wells open during the longer term extraction trial would result in an increased amount of extraction within the deep vadose soils.



### **2.3 Emission Mass Loading Test**

Subsequent to the short-term extraction trials, and prior to the long-term extraction trial, an emission mass loading test was performed to estimate total TCE emissions expected during total system activation. The test was run with only the five deep wells open.

Prior to startup, pressure readings were taken from most recovery wells and piezometer PZ-3. Pressure readings were not taken from wells RW-2, 5, and 6 due to flooded well vaults. System startup and shutdown occurred at 13:20 and 13:26, respectively, January 2, 1992.

Five samples, four from the emission stack and one field blank, were taken during the test. Analytical results indicated an average emission concentration of 20 mg/L of TCE.

The following formula was used to convert reported analytical concentrations to mass loading rates:

$$X_t = \frac{X_m * Q}{35.3 \text{ ft}^3/\text{m}^3 * 454000 \text{ mg/lb}}$$

Where:

$X_m$  = reported laboratory analytical contaminant concentration (mg/m<sup>3</sup>)

$Q$  = air flow rate (ACFH)

$X_t$  = effluent contaminant mass loading rate (lb/hr)

System flow rates ( $Q$ ) averaged approximately 200 ACFM during the emission mass loading test. This flow rate, coupled with laboratory analytical reported contaminant concentrations, yields an initial contaminant mass loading rate of about 360 pounds per day. This mass loading rate allows for approximately 55 days of continuous system operation without exceeding the permitted emission rate of 10 tons per year.

### **2.4 Long-term Extraction Trial**

A long-term extraction trial was performed simultaneously on both the shallow and deep well systems to test the performance of the total system. The long-term extraction trial included soil gas sampling, active pressure monitoring, and air temperature and flow rate monitoring. Soil

gas sampling was performed periodically from the system emission stack and intermittently from selected recovery wells and soil vapor probes nested at 15' intervals in piezometer PZ-3. Active pressure readings were taken during the test to help estimate the areal extent of vacuum influence. Air temperature and flow rates through the emission stack were monitored during sampling events to confirm contaminant mass loading rates.

Analytical results indicated a first day emission concentration of 52 mg/L or a mass loading rate of approximately 900 pounds per day. However, this rate declined to anticipated levels of approximately 20 mg/L or 360 pounds per day during on the third day of the test. Emission concentrations declined slowly during the next 87 days, falling from 20 to 0.6 mg/L or 360 to 11 lbs/day. Analytical results shown in Table 1 were plotted and fitted to a curve shown in Figure 1. Emission concentrations indicate a declining logarithmic rate. Total extracted TCE emissions during the time plotted are approximately 5.4 tons.

Vacuum pressure readings at PZ-3 were monitored during the long-term extraction trial to estimate vacuum influence of the SVE system. Readings fluctuated, showing increases and decreases in vacuum pressure from reading to reading; however, vacuum pressures showed overall increases with time during the test. Reading fluctuations are believed to be the result of changes in ambient soil pressure due to fluctuations in barometric pressure and city well operations.

Long and short-term extraction trial results indicate that soil-vapor extraction is an effective means of TCE removal from the vadose zone. Results indicate especially favorable SVE conditions for the coarse-grained soil horizon 20 to 45 feet below grade and immediately above the Jackson Clay. However, due to leaks in the deep recovery well piping, an accurate estimate of the capacity of this SVE system is not possible unless some intrusive means of measuring individual wellhead air flow rates can be implemented.

TABLE 1  
CARRIER COLLIERVILLE SVE DATA  
NORTH REMEDIATION SITE

SAMPLE LOCATION	SAMPLE ID #	TCE CONCENTRATION	SAMPLING DATE
		ug/l	
EMISSION STACK	ES1	21028	1/2/92
EMISSION STACK	ES2	17792	1/2/92
EMISSION STACK	ES3	16040	1/2/92
EMISSION STACK	ES4	23177	1/2/92
EMISSION STACK	ES21*	53201	1/9/92*
EMISSION STACK	ES22	51634	1/9/92
EMISSION STACK	ES24	25189	1/10/92
EMISSION STACK	ES25	35892	1/10/92
EMISSION STACK	ES26	25888	1/11/92
EMISSION STACK	ES27	15139	1/13/92
EMISSION STACK	ES28	18818	1/14/92
EMISSION STACK	ES29	12777	1/15/92
EMISSION STACK	ES30	16093	1/16/92
EMISSION STACK	ES31	15464	1/16/92
EMISSION STACK	ES32	12587	1/20/92
EMISSION STACK	ES33	12537	1/20/92
EMISSION STACK	ES34	12847	1/22/92
EMISSION STACK	ES35	9944	1/24/92
EMISSION STACK	ES36	10455	1/24/92
EMISSION STACK	ES37	9970	1/29/92
EMISSION STACK	ES38	9417	1/31/92
EMISSION STACK	ES39	8842	1/31/92
EMISSION STACK	ES40	9035	2/2/92
EMISSION STACK	ES43	1118	2/21/92
EMISSION STACK	ES44	783	2/21/92
EMISSION STACK	ES45	840	3/26/92
EMISSION STACK	ES46	1074	3/26/92
EMISSION STACK	ES47	620	4/6/92

\* LONG TERM EXTRACTION TRIAL START-UP

TABLE 1

## CARRIER COLLIERVILLE SVE DATA

## NORTH REMEDIATION SITE

SAMPLE LOCATION	SAMPLE ID #	TCE CONCENTRATION ug/l	SAMPLING DATE
PZ-3, 15'	PZ315	< 0.10	12/17/91
PZ-3, 15'	PZ-151	226	12/30/91
PZ-3, 15'	PZ3315	887	1/9/92
PZ-3, 15'	PZ3415	122	1/10/92
PZ-3, 15'	PZ3515	294	1/11/92
PZ-3, 30'	PZ330	11566	12/17/91
PZ-3, 30'	PZ-301	22114	12/30/91
PZ-3, 30'	PZ-302	17529	12/31/91
PZ-3, 30'	PZ3330	19649	1/9/92
PZ-3, 30'	PZ3430	24495	1/10/92
PZ-3, 30'	PZ3530	25100	1/11/92
PZ-3, 30'	PZ3630	17422	1/15/92
PZ-3, 30'	PZ3730	13156	1/22/92
PZ-3, 45'	PZ345	5877	12/17/91
PZ-3, 45'	PZ-451	10740	12/30/91
PZ-3, 45'	PZ-452	22359	12/31/91
PZ-3, 45'	PZ3345	22011	1/9/92
PZ-3, 45'	PZ3445	21327	1/10/92
PZ-3, 45'	PZ3545	17100	1/11/92
PZ-3, 45'	PZ3645	15270	1/15/92
PZ-3, 45'	PZ3745	9713	1/22/92
PZ-4, 15'	PZ415	1404	12/17/91

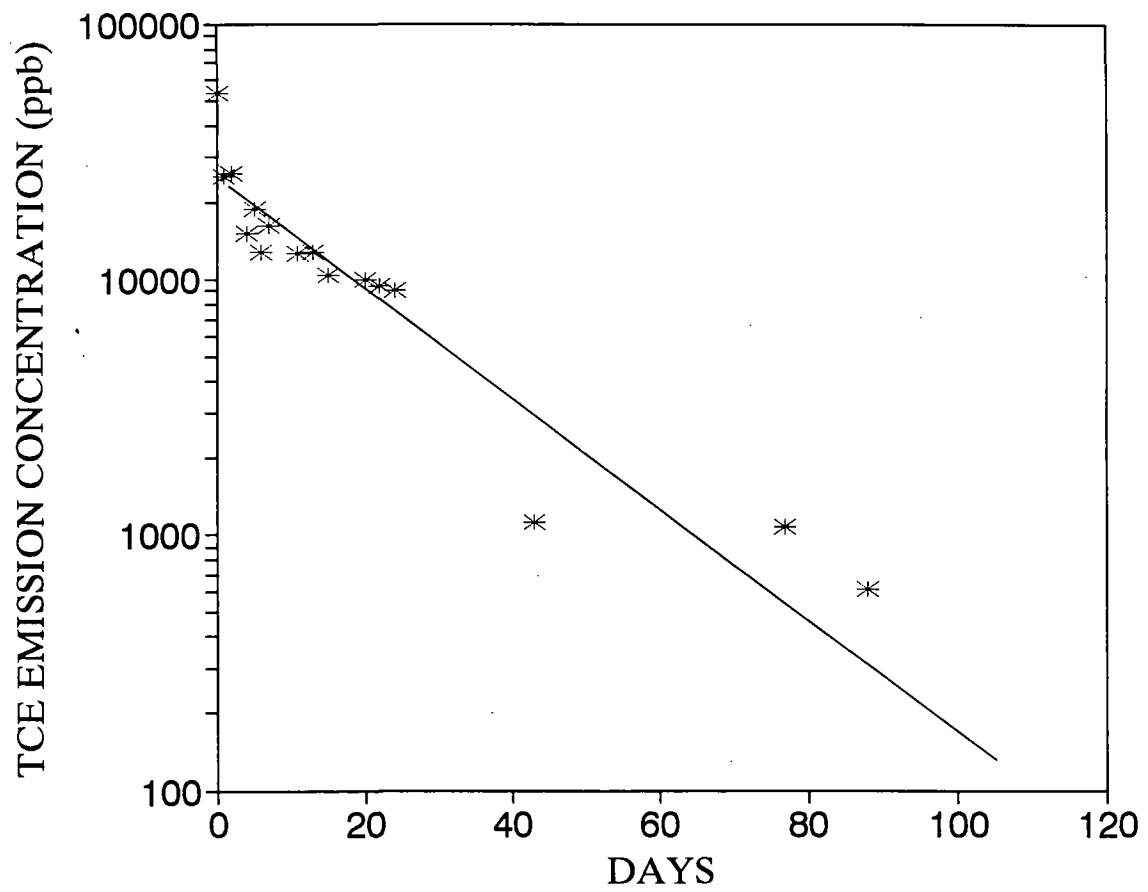
TABLE 1

## CARRIER COLLIERVILLE SVE DATA

## NORTH REMEDIATION SITE

SAMPLE LOCATION	SAMPLE ID #	TCE CONCENTRATION ug/l	SAMPLING DATE
RECOVERY WELL 1	RW101	20400	12/17/91
RECOVERY WELL 2	RW201	15292	12/17/91
RECOVERY WELL 3	RW301	38	12/17/91
RECOVERY WELL 4	RW401	22404	12/17/91
RECOVERY WELL 4	RW-401	7745	12/30/91
RECOVERY WELL 5	RW501	116	12/17/91
RECOVERY WELL 6	RW601	56380	12/17/91
RECOVERY WELL 7	RW701	52381	12/17/91
RECOVERY WELL 8	RW801	56788	12/17/91
RECOVERY WELL 8	RW-801	135605	12/30/91
RECOVERY WELL 8	RW-802	148676	12/31/91
RECOVERY WELL 9	RW901	98009	12/17/91
AMBIENT AIR	ESB	6.8	1/2/92
AMBIENT AIR	EBX1	15	1/13/92
AMBIENT AIR	EBX3	0.78	1/15/92
AMBIENT AIR	EBX3	0.5	2/4/92
SPIKE	EBX2	508	1/13/92
SPIKE	EBX4	737	1/15/92
SPIKE	EBX5	892	2/4/92
SPIKE	EBX7	796	2/4/92

**FIGURE 1**  
NORTH REMEDIATION SITE SVE SYSTEM



### **3.0 SAMPLING METHODS AND QA/QC**

Pressure levels were measured using a hand-held Dwyer Series 475 Digital Manometer. Pressure data were given in inches of water, and variations in background pressures were assumed to be a result of fluctuations in ambient barometric pressures.

Trichloroethylene soil gas concentration levels were measured through field sampling and subsequent laboratory sampling. Field sampling was performed using an airtight Hamilton 50-ml syringe to extract "active" soil gas samples through emission stack, recovery well, and piezometer sample ports.

Active conditions are present at the emission stack, as air flows by the sample port during normal system operation. Active sample conditions were created at wellhead and PZ point sampling ports using a small vacuum pump run continuously during sampling. The pump was run until a minimum of one well volume of soil gas had been purged. One well volume of soil gas was calculated as the product of the length of the recovery well and its cross sectional area. When one well volume was purged, an active sample was collected through the recovery well or vacuum pump soil gas sampling port.

Once collected, samples were injected into 50 ml evacuated glass cylinders. Samples were then labeled, tagged, and sealed prior to shipment to Target Laboratories for analysis. Samples were analyzed by EPA Method 601 on a GC equipped with an ECD, but using direct injection instead of purge and trap.

Specific analytes standardized for the ECD analysis were:

- 1,1-dichloroethene
- cis-1,2-dichloroethene
- methylene chloride
- 1,1,1-trichloroethane
- trans-1,2-dichloroethene
- trichloroethene (TCE)
- chloroform
- 1,1,2-trichloroethane

1,1-dichloroethane  
tetrachlorethane  
carbon tetrachloride

Vinyl chloride was not included as an analyte because VC detection requires a more expensive mass spectrometry, and the level of vinyl chloride is expected to be very low.

Sample spikes and field blanks were sent to assess laboratory test data quality. Spikes were sampled from a Tedlar bag filled with a gas standard containing 107 parts per million by volume, or 671 mg/m<sup>3</sup> by weight, TCE in air. Field blanks were samples of ambient air taken during selected sampling events. Spike results from four samples reported 80 to 140 percent of the anticipated spike concentration. Table 2 lists spike results:

<b>Table 2 Spike Results</b>			
<b>Sample ID</b>	<b>Date</b>	<b>TCE Concentration (mg/m<sup>3</sup>)</b>	<b>Percent Recovery</b>
EBX2	1/13/92	508	76
EBX4	1/15/92	737	110
EBX5	2/4/92	892	133
EBX7	2/4/92	796	119
EBX8*	5/19/92	514	77
EBX9*	5/19/92	483	72
EBX10	5/19/92	647	96
EBX11	5/19/92	448	67

**Note:**

- \* To help verify laboratory accuracy, two spikes (EBX8 and EBX9) were sent to an alternative laboratory simultaneously with two spikes (EBX10 and EBX11) sent to Target.



**APPENDIX B**  
**GROUNDWATER MONITORING WORK PLAN**

## **Table of Contents**

1.0	INTRODUCTION .....	B-1
2.0	GROUNDWATER MONITORING PROGRAM REMEDIAL DESIGN FIELD ACTIVITIES .....	B-3
2.1	Groundwater Recovery Model .....	B-3
2.2	Well Installation .....	B-4
2.3	Well Development .....	B-7
2.4	Well Sampling and Analysis .....	B-8
2.5	Vertical Flow Characteristics .....	B-10
3.0	MONITORING PROGRAM .....	B-11

## **List of Figures**

Figure B-1	Proposed Downgradient Monitoring Well Location and City Well Field Capture Zone .....	B-6
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## **1.0 INTRODUCTION**

As required by the ROD dated September 3, 1992, groundwater containment will be performed via the existing extraction wells at Water Plant 2 and, if necessary, additional supplemental extraction well(s). Groundwater treatment will be performed via the existing air strippers at Water Plant 2.

Groundwater treatability at this site has already been assessed through aquifer testing and operation of the air strippers at Water Plant 2. Aquifer test results indicate Water Plant 2 has been containing most, if not all, of the groundwater plume during historical plant operations. Historical operating rates will be increased during remediation and will result in a much larger zone of capture. This larger capture zone will provide a higher confidence level that containment is being achieved.

### **Objectives**

The following objectives will be addressed through the implementation of this work plan.

#### ***Groundwater Monitoring Design Objectives:***

- Verify containment by the Water Plant 2 extraction system
- Obtain values for vertical hydraulic conductivity and vertical hydraulic gradient in the Memphis Sand.

#### ***Data Quality Objectives:***

- Use analytical methods capable of detecting confirmed site constituents at levels equal to or below contaminant concentrations required by remedial goals, ARARs.
- Use a sampling/analysis system which can yield useful and reproducible data for comparison with historical and future sampling data.
- Obtain aquifer data of sufficient quality to make any needed modifications to the existing groundwater remediation system.

#### ***Methods of Obtaining Data Quality Objectives:***

- Use analytical methodologies capable of detecting target site contaminants.

- Set criteria for sampling event completeness, precision, accuracy, and minimum detection levels.

## **2.0 GROUNDWATER MONITORING PROGRAM REMEDIAL DESIGN FIELD ACTIVITIES**

This section summarizes additional drilling and sampling activities needed to acquire information that can confirm that Water Plant 2 is capable of providing containment. These activities include the installation and sampling of observation wells downgradient from Water Plant 2. Information produced from these wells include groundwater analytical data downgradient from Water Plant 2 and values for vertical hydraulic conductivity ( $K_v$ ) and vertical hydraulic gradient ( $I_v$ ).

### **2.1 Groundwater Recovery Model**

The purpose of executing this model was twofold: first, to calculate capture zones of the two municipal wells by using a calibrated flow model coupled with advective particle tracking algorithms; and second, to locate the downgradient monitoring well to verify capture to the west of the West City Well.

Capture zones calculated using RESSQC in the East Well pump test report is suspect in that a) the aquifer parameters utilized have not been validated via calibration b) drawdowns calculated using RESSQC are based on the Theis equation; given the aquifer conditions, drawdowns should also be calculated using the Theis equation; and c) the aquifer test data and the lithologic interpretation of the site indicate that a recharge boundary is present in the southeastern portion of the site, where aquifer conditions go from confined to unconfined; this condition was not accounted for in the RESSQC model. CAPZONE, an analytical flow model which is capable of calculating drawdowns using the Theis equation, superimposing these drawdowns on a regional water level field, and accounting for simple boundary conditions through image well theory, was chosen to reevaluate the aquifer. CAPZONE flow model outputs are compatible with an advective particle tracking program. GWPATH was used to calculate 20-year reverse pathlines to the municipal wells for the simulation.

The pumping test data collected during the East Well test was chosen as representative of the stressed water level field, and the water levels collected immediately prior to the conditions. Drawdowns were simulated at a pumping rate equivalent to the test discharge rate, and over a period of time equivalent to the test period (4.75 days). Initially, the aquifer parameters used

in the RESSQC simulation were used for drawdown simulation. However, the simulated drawdowns using these parameters were approximately twice those observed during the actual test. Additionally, the simulated drawdown at the East Well was much less than that actually observed during the test. A consequent increase in transmissivity allowed a reasonable match between simulated and observed drawdowns in all but the pumping well. The simulation assumes a well efficiency of 100% because the well efficiency of the East Well was unknown, and drawdowns in that well may have reflected poor well efficiency.

A reevaluation of the pump test data revealed that test curves showed a flattening over time, typical of either intersecting a recharge boundary, the transition period to aquifer dewatering in an unconfined aquifer, or leakage through a confining unit. Drawdown was found to be intersecting a recharge boundary not accounted for in the RESSQC model. The new simulation was ran simulating a recharge boundary. The same parameters used for the RESSQC model were used for the new model with simulated drawdowns matching fairly well with observed drawdowns.

The new model simulation was run with both East and West wells pumping at a rate of 500 gpm. A reverse path function was utilized to illustrate flow to the pumping wells over a 20 year period.

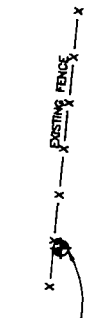
Figure B-1 depicts the capture zone of Water Plant 2, and also the proposed location of the downgradient monitoring well. The location chosen is also directly downgradient of the identified plume, so it will detect contaminants flowing under the West City Well, if present.

## **2.2 Well Installation**

### ***Well Boring***

A cluster of three monitoring wells are to be installed to depths of approximately 420, 320, and 220 feet and screened in the Memphis Sands downgradient of Water Plant 2 outside of the immediate capture zone. The deepest boring will be installed first using the following procedures:

- A 4-inch ID pilot hole will be advanced to the top of the Jackson Clay using water-rotary techniques. If there is difficulty in keeping the borehole open, drilling mud will be gradually added to the water.
- Once the boring has reached the Jackson Clay, split spoon samples will be taken continuously until 5-feet of clay is located with no silt or sand present. If 5 contiguous feet of clay is found, the borehole will be overdrilled to a 14-inch ID borehole and a 10-inch ID steel surface casing pressed into the Jackson Clay. The surface casing will then be tremie grouted with a pumpable mixture of Portland Cement, or equivalent and sand from the sides and bottom of the casing to ensure a continuous seal.
- If 5 contiguous feet of clay is not found, the 4-inch ID pilot hole will be overdrilled to a 14-inch borehole and advanced 10-feet into the Jackson Clay. The casing will be installed by lifting just off the bottom of the borehole and installing a groutshoe or packer. The casing will then be pressure grouted using a pumpable mixture of Portland Cement or equivalent and sand through the groutshoe up to the surface to seal the borehole.
- After allowing the grout to set for a minimum of 16-hours, a 4-inch ID pilot boring will be advanced through the Jackson Clay, and into the top of the Memphis Sands. Water level measurements will be monitored in the pilot hole until stabilized. The purpose of the water level measurement is to confirm or deny monitoring well cluster location for the ensuing monitoring wells.
- Once a stabilized water level reading has been recorded, the 4-inch ID pilot boring will be overdrilled to an 8-inch ID boring and then continued to the termination depth using mud rotary techniques. The drilling mud used will contain no more than 3% solids.



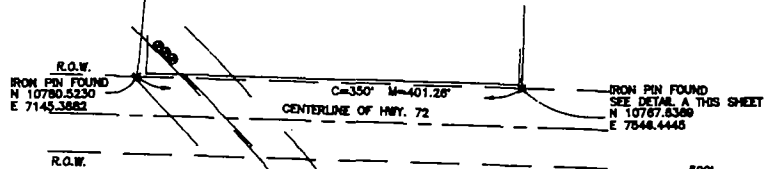
PK-NAIL SET  
N 11150.8081  
E 7367.8606

PK-NAIL SET  
N 11150.8081  
E 7369.3568

I.B.M.  
CHISEL MARK IN EAST EDGE OF  
TOP OF CONCRETE FOUNDATION  
OF THE MOST NORTHERLY OF  
THE WESTERN LIGHT POLES  
ELEV. = 366.62



MERRIE OLDS



- LEGEND**
- MONITORING WELLS (MW) DEEP
  - MONITORING WELLS (MW) SHALLOW
  - MW-9 MONITORING WELLS NUMBER
  - PROPOSED MONITORING WELL

R.O.W.

N 10678.4100  
E 7514.2200

500'

#100  
N 10352.86  
E 7515.73

■ MW-55  
N 10283.2850  
E 7587.3240

MW-59  
N 10278.3133  
E 7632.4498

#8  
N 10288.27  
E 7973.89  
ELEV. 360.64

MW-57  
N 10743.5710  
E 8363.8511

MW-58  
N 10751.2105  
E 8363.8511

#6  
N 10186.15  
E 8691.61

APT-1  
N 10080.8811  
E 8482.9218

APT-2  
N 10068.8751  
E 8446.4324

MW-19  
N 10230.4483  
E 8459.2370

MW-49  
N 10083.8874  
E 8687.2818

MW-21  
N 9735.7084  
E 8487.7797

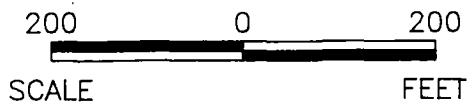
MW-37  
N 9824.7082  
E 8242.0779

MW-41  
N 9571.8793  
E 79183.412

MW-47  
N 9858.3145  
E 9143.0717

MW-23  
N 9583.5408  
E 9118.5047

#1  
N 10000.00  
E 10000.00  
ELEV. 357.33



■ MW-51  
N 9823.7171  
E 7057.3072

Environmental and Safety Designs, Inc.



5724 SUMMER TREES DR. MEMPHIS, TN. 38134 (901)372-7962  
NASHVILLE, TN. PENSACOLA, FL. AND RALEIGH, NC.

COLLIERVILLE SITE  
PROPOSED DOWNGRADIENT  
MONITORING WELLS

DWG DATE: 03/04/94 DWG NAME: CARNEW1E



### ***Well Casing and Screen Installation***

Depth and screened interval selection of each monitoring well is selected to ensure that any contaminant that is not captured by the city wells, either horizontally or vertically, will be detected at the monitoring well over a depth interval of 100 feet greater than the depth of the city wells and up to approximately 50 feet below the bottom of the Jackson Clay. Standard borehole geophysical tools will be run in the first well and consist of a resistivity, spontaneous potential, and gamma ray combination probe. The data generated from this probe will be used to determine lithology, i.e. the sequence of sands and clays, screen placements and lengths based on this lithologic sequence, and depths of the ensuing wells.

Each well boring will be converted to a monitoring well using 4-inch ID Schedule 40 PVC casing and 20-feet of 0.01-inch slotted Schedule 40 PVC screen. A 20/40-graded environmental filter pack material will be emplaced into the annular space and extended to approximately 2 feet above each screened interval. An attempt will be made to tremie the sand around the screened interval, if this fails, the sand will be floated to the bottom after the area around the screen is cleaned. Two feet of bentonite chips will then be placed above the sand pack and hydrated to create a bentonite seal. The remaining intervals will be backfilled with a high solids bentonite mud grout, mixed to 10.2 pounds/gallon. Finally, a 2'x2'x6" concrete pad will be constructed around a bolt-down manhole at each monitoring well to prevent surface water from entering the well.

An activity calculation was made to determine if PVC is appropriate for the contaminants of concern at the site. A concentration of 0.140 ppm TCE was used as the VOC concentration since this sample came from the West Well which is in close proximity to the proposed downgradient monitoring well. Dividing the VOC concentration by the solubility of TCE in groundwater (1100 mg/l) yields an activity of 0.00013, much less than the determining factor of 0.25 for the application of PVC.

### **2.3 Well Development**

Each well will set at least 24 hours after grouting before initiating the development procedures. Each well will be developed in the following sequence; 1) pumped clean, 2) jet to break up

screen material, and 3) pumped clean. Each well will be developed until water is visibly free of drilling mud and other sediments.

## 2.4 Well Sampling and Analysis

Groundwater samples will be collected quarterly beginning within one week after well construction.

### *Monitoring Well Sampling Procedures*

1. Place a dedicated plastic or aluminum foil sheet around the wellhead to provide an area where equipment can be placed temporarily without risk of contamination.
2. Don a new pair of disposable nitrile gloves. Disposable gloves will be worn whenever the sampler handles samples and/or sampling equipment.
3. Measure the static water level in the well with an electronic water level meter and record the depth in the project field logbook. All water level measuring devices must be accurate to within one-tenth of a foot or better.
4. Measure the depth of the well with a pre-cleaned weighted steel tape.
5. Purge a minimum of three well volumes of water using a dedicated, pre-cleaned submersible pump and tubing. The pump should be positioned within the upper few feet of the water column to achieve thorough purging. Purged waters will be treated at the NRS.

The volume of water in the well casing will be calculated as follows:

$$Volume = ( A - B ) \times ( C )$$

Where:

V = the volume of water, gallons

- |   |   |   |
|---|---|---|
| A | = | the total depth of the well, feet             |
| B | = | the depth to water in the well, feet          |
| C | = | 0.17 for 2-inch ID wells or 0.66 for 4" wells |

After each purged volume, pH, temperature, and conductivity will be monitored for stabilization. Field measurements will be considered stabilized according to USEPA's Environmental Compliance Branch, *Standard Operating Procedures and Quality Assurance Manual*, Section 6.3—Specific Quality Control Procedures. Stabilization criteria is as follows:

- Temperature — within  $\pm 1.0$  °C
- pH — within  $\pm 0.5$  standard units
- Conductivity — within  $\pm 10\%$  from the duplicate

If stabilization has not occurred after three well volumes have been purged, additional water will be purged until readings stabilize. The maximum allowable time between purging and sampling is six hours. If the well has not recovered sufficiently after this time, the well will not be sampled.

6. **VOC Sampling:**

VOC samples will be analyzed according to EPA Method 624. Samples for VOC analysis will be gently poured into a clean, pre-labeled, 40 ml vial with a Teflon-lined septum. Pouring should be performed to create a convex meniscus at the rim of the sample vial. The cap should then be applied at an angle and sealed. No air bubbles should be visible once the vial is sealed. If bubbles are visible, the vial should be discarded, and the procedure must be repeated.

**Inorganic Sampling:**

Samples for inorganic analysis will be poured into 1-liter polyethylene or glass jars.  $\text{HNO}_3$  (nitric acid) will then be added to lower sample pH below 2. Proper preservation can be checked by pouring a small amount of the sample into a clean cup and checking it with pH paper.

7. Samples will then be placed in a cooler containing ice and water placed in sealable plastic bags, or blue ice, to provide temperature preservation at 4°C. Coolers will be shipped overnight to the laboratory at the end of each work day. All samples to be shipped for analysis will be delivered to the laboratory within 24 hours of collection.

## **2.5 Vertical Flow Characteristics**

Vertical flow characteristics of the Memphis Sand are needed to estimate the existing extent of the groundwater contaminant plume and potential well capture zones. The two vertical flow characteristics targeted by this study are vertical hydraulic conductivity ( $K_v$ ) and vertical hydraulic gradient ( $I_v$ ).

$K_v$  will be estimated by reanalyzing the aquifer pump test data. This can be done since the East City Well partially penetrates the Memphis Sand Aquifer, therefore, inducing vertical flow components in the vicinity of the well.

$I_v$  can be estimated through piezometric surface data from nested piezometers installed at varying depths. Such a piezometer arrangement will be present after the installation of the three downgradient monitoring well, and the East well and APT-1. Water Plant 2 will be shut down for at least 72 hours to allow the aquifer to recovery to ambient conditions. After this time, water levels within the wells will be measured and compared to estimate a vertical gradient.

### **3.0 MONITORING PROGRAM**

Scope and frequency of the groundwater monitoring program are currently under development by Carrier and USEPA. This monitoring program will assess the ongoing performance of Water Plant 2 and will include periodic sampling of Water Plant 2, air stripper effluent, and the downgradient observation wells.

The new downgradient observation wells and MW-58 will be monitored on a quarterly basis for one year to ensure containment of the contaminant plume within the Memphis Sand. Four quarterly measurements will be fit with an exponential regression technique that will be extrapolated to the next scheduled sampling event. If the predicted value at either of these monitoring wells exceeds 15 ppb, it can be concluded that containment is not being achieved by Water Plant 2.

MW-3 and Water Plant 2 will be included in the quarterly monitoring program. Monitoring of MW-3 is intended to provide first indication of any reduction in contaminant transport from MPA soils to the Memphis Sand Aquifer, especially once full-scale SVE has proceeded. Monitoring will commence on installation of the new downgradient wells to provide a baseline.

**APPENDIX C**  
**FIELD SAMPLING ACTIVITIES PLAN**

## **Table of Contents**

1.0	INTRODUCTION .....	C-1
2.0	SOILS TREATABILITY STUDY SAMPLING ACTIVITIES .....	C-2
2.1	Soil-vapor Sampling and Analysis .....	C-2
2.2	Soil Sampling and Analysis .....	C-2
3.0	GROUNDWATER SAMPLING ACTIVITIES .....	C-4
3.1	Well Development .....	C-4
3.2	Water Level Measurements .....	C-4
3.3	Groundwater Sampling Procedures .....	C-4
4.0	QUALITY CONTROL SAMPLES .....	C-7
5.0	EQUIPMENT DECONTAMINATION .....	C-8
6.0	SAMPLE MANAGEMENT .....	C-11
6.1	Sample Labelling .....	C-11
6.2	Custody Seals .....	C-13
6.3	Chain-of-Custody .....	C-13
6.4	Daily Logs (Field Log) .....	C-16
6.5	Corrections to Documentation .....	C-17
6.6	Corrective Action .....	C-18
6.7	Out-of-Control Situations .....	C-18
7.0	CALIBRATION PROCEDURES AND FREQUENCY .....	C-20
8.0	PREVENTIVE MAINTENANCE .....	C-21

## **List of Figures**

Figure 6-1	Sample Bottle Labels .....	C-12
Figure 6-2	Sample Seals .....	C-14
Figure 6-3	Chain-of-Custody Forms .....	C-15

## **List of Tables**

Table 4-1	Quality Control Sample Collection Frequencies .....	C-7
Table 6-1	Sample Designation System .....	C-13
Table 7-1	Field Equipment Calibration .....	C-20

Table 8-1  
Field Testing Equipment . . . . . C-21



## 1.0 INTRODUCTION

This appendix describes sampling procedures for this project. The USEPA Region IV-Environmental Compliance Branch, *Standard Operating Procedures and Quality Assurance Manual*, February 1991 (EPA SOP QAM) was used as a basis for these sampling procedures.

## **2.0 SOILS TREATABILITY STUDY SAMPLING ACTIVITIES**

A soil-vapor extraction pilot study will be performed in the TCE spill and leak areas during remedial design. The pilot study will include a series of SVE parameter evaluation tests and point permeability tests. To perform these tests, a network of SVE wells and monitoring probes will be installed. During installation of SVE wells and probes, soil gas and soil samples will be collected and screened for TCE concentrations.

### **2.1 Soil-vapor Sampling and Analysis**

Soil-vapor samples will be drawn from each vapor probe location (or well boring) prior to the performance of each PET and PPT. Soil-vapor samples will be analyzed onsite for total VOCs using either an HNu model photoionization detector or an organic vapor monitor. The total volatile organic compounds are expected to consist of primarily TCE and its degradation products.

Additional vapor samples will be collected from the effluent vapor sampling port before, during, and after each test and from vapor probes before and after each test. Samples will be collected by the soil gas subcontractor in 50 ml evacuated glass cylinders. These additional samples will be submitted for onsite or offsite laboratory analysis according to modified EPA Method 601/602 using an ECD equipped GC to analyze for VOCs.

### **2.2 Soil Sampling and Analysis**

A new pair of nitrile disposable gloves will be donned prior to collecting each soil sample. Using 2-inch outer diameter, 24-inch long, stainless steel split spoons, soil samples will be collected ahead of the augers at 10-foot intervals beginning at 5 feet bgs. Split spoons may be hydraulically pushed or hammered at the site geologist's discretion. Contents of all auger spoils will be containerized in 55-gallon drums for subsequent on-site treatment.

Soil will be transferred to 125 ml precleaned glass jars with septum lids for submittal to Woodson-Tenent Laboratories for VOC analysis by the co-distillation method approved for this site by the USEPA during the RI.

To analyze for humic and fulvic acids, two additional samples will be collected from a minimum of one deep and one shallow SVE well boring installed during the treatability study. The actual depths from which the samples will be obtained will be determined in the field.

All soil samples will be stored in a cooler containing ice and water placed in sealable plastic bags, or blue ice, to provide temperature preservation at 4°C. All samples to be shipped for analysis will be delivered to the laboratory within 24 hours of collection.

### **3.0 GROUNDWATER SAMPLING ACTIVITIES**

A cluster of three monitoring wells will be installed and sampled downgradient from the existing extraction system at Water Plant 2. The wells will be screened at depth intervals ranging from near the top of the Memphis Sand to 100 feet below the elevation of the West Well, with exact intervals determined by the site geologist logging the borehole.

#### **3.1 Well Development**

Each well will set at least 24 hours after grouting before development procedures begin. Each well will be developed in the following sequence; 1) pumped clean, 2) jet to break up screen material, and 3) pumped clean. Each well will be developed until water is visibly free of drilling mud and other sediments.

#### **3.2 Water Level Measurements**

Static groundwater levels will be measured in each monitoring well 24 hours following development. Each well shall be gauged on the same day as development. Well gauging will consist of measuring the depth to water using a decontaminated oil and water interface probe. The measurements will be made to an accuracy of one-hundreth of a foot. Well depth will be measured using a decontaminated weighted steel tape with an accuracy of at least one-tenth of a foot. All readings will be made at a clearly marked reference point at the top of each well casing. Each well reference point will be surveyed to a common datum and/or mean sea level to allow construction of a groundwater surface contour map.

#### **3.3 Groundwater Sampling Procedures**

Groundwater samples will be collected quarterly beginning one week after well construction. The following steps outline monitoring well sampling procedure.

- Place a dedicated plastic or aluminum foil sheet around the wellhead to provide an area where equipment can be placed temporarily without risk of contamination.
- Don a new pair of disposable nitrile gloves. Disposable gloves will be worn whenever the sampler handles samples and/or sampling equipment.

- Measure static well water level with an electronic water level meter and record the depth in the project field logbook. All water level measuring devices must be accurate to within one-tenth of a foot or better.
- Measure the depth of the well with a pre-cleaned weighted steel tape.
- Purge at least three well volumes of water using a pre-cleaned submersible pump and Teflon tubing. The pump should be positioned within the upper few feet of the water column to achieve thorough purging. Purged waters will be retained until the regulatory status of the water is determined.

The volume of water in the well casing will be calculated as follows:

$$\text{Volume} = ( A - B ) \times ( C )$$

Where:

V	=	represents the volume in gallons,
A	=	represents the total well depth,
B	=	represents the depth to water level, and
C	=	0.17 for 2" wells or 0.66 for 4" wells

After each purged volume, pH, temperature, and conductivity will be monitored for stabilization. Field measurements will be considered stabilized according to USEPA's Environmental Compliance Branch, *Standard Operating Procedures and Quality Assurance Manual*, Section 6.3—Specific Quality Control Procedures.

- **Stabilization Criteria:**

Temperature	—	within $\pm 1.0$ °C
pH	—	within $\pm 0.5$ standard unit
Conductivity	—	within $\pm 10\%$ from the duplicate

If stabilization has not occurred after three well volumes have been purged, additional water will be purged until readings stabilize. The maximum allowable time between purging and sampling is six hours. If the well has not recovered sufficiently after this time, the well will not be sampled.

- **VOC Sampling:**

VOC samples will be analyzed according to EPA Method 624. Method detection limits for TCE and its degradation products are below maximum contaminant levels for those constituents.

Samples for VOC analysis will be gently poured into a clean, pre-labeled, 40 ml vial with a Teflon-lined septum. Pouring should be performed to create a convex meniscus at the rim of the sample vial. The cap should then be applied at an angle and sealed. No air bubbles should be visible once the vial is sealed. If bubbles are visible, the vial should be discarded, and the procedure must be repeated.

- **Inorganics Sampling:**

Samples for inorganics analysis (lead and zinc) will be poured into 1-liter polyethylene or glass jars.  $\text{HNO}_3$  (nitric acid) will then be added to lower sample pH of below 2. Proper preservation can be checked by pouring a small amount of the sample into a clean cup and checking it with litmus paper.

Samples will then be placed in a cooler containing ice and water-placed in sealable plastic bags, or blue ice, to provide temperature preservation at 4°C. Coolers will be shipped overnight to the laboratory at the end of each work day. All samples to be shipped for analysis will be delivered to the laboratory within 24 hours of collection.

#### 4.0 QUALITY CONTROL SAMPLES

Precision will be assessed by evaluating results of duplicate and matrix spike duplicate samples. Accuracy will be assessed by evaluating field blanks, trip blanks, matrix and surrogate spikes, and reagent blanks and blank spike samples. Table 4-1 summarizes QC sampling frequencies.

Table 4-1 Quality Control Sample Collection Frequencies		
Quality Control Sample	Frequency of Collection	Additional Sample Volumes
Trip Blank (volatiles only)	One per sample shipping cooler containing samples to be analyzed for volatiles	3x40 ml. VOA vials with Teflon-lined septa
Rinsate Blank	Collected every day or every ten samples, but only analyzed every other day.	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals
Field Blank	One per sampling event or every ten samples.	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals
Material Blank	One blank sample of any non-packaged material used for SVE/Monitoring well completion.	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals
Duplicates	One per 10 samples per matrix	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals
Matrix Spike/Matrix Spike Duplicate Samples	One per 20 samples per matrix; duplicate sample may be used for matrix spike	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals*

**Notes:**

P,G — Polyethylene or Glass

- \* — Matrix spike/matrix spike duplicate requirements are slightly different for the inorganics analysis. The inorganics analysis will only have one sample to spike, no duplicate spike sample will be necessary.

## **5.0 EQUIPMENT DECONTAMINATION**

The drill rig will be steam cleaned and wire brushed before being brought onsite. The drill rig will then be inspected to insure there is no leakage of oil, grease, hydraulic fluid, etc. Drilling equipment will be decontaminated between drilling of each boring using the decontamination procedures listed below.

1. Decontamination of equipment will be performed on the onsite decontamination pad.
2. Steam clean with a pressure washer using tap water and laboratory detergent to remove particulate matter and surface films.
3. Pressure rinse with tap water.
4. Rinse thoroughly with deionized water.
5. Rinse twice with pesticide-grade isopropanol.
6. Rinse thoroughly with organic-free water and allow to air dry.
7. Wrap with aluminum foil or polysheeting to prevent contamination.

All non-dedicated stainless steel sampling equipment and the split spoon samplers will be decontaminated between boreholes using the decontamination procedures listed below.

1. Steam clean with a pressure washer using tap water and laboratory detergent to remove particulate matter and surface films.
2. Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse twice with pesticide-grade isopropanol.



5. Rinse thoroughly with organic-free water and allow to air dry.
6. Wrap with aluminum foil or polysheeting to prevent contamination.

All non-dedicated stainless steel sampling equipment and the split spoon samplers will be decontaminated between samples using the decontamination procedures listed below.

1. Equipment will be washed thoroughly with laboratory detergent (i.e. Liquinox) and followed by a hot water rinse using a brush to remove any particulate matter or surface film.
2. Equipment will be rinsed with potable water to remove any remaining detergent.
3. Following the potable water rinse, the equipment will be rinsed with deionized water.
4. Rinse twice with pesticide-grade isopropanol.
5. Rinse with organic-free water and air dry.
6. Sampling equipment will be wrapped in aluminum foil until ready for use. Non-sampling equipment may be wrapped in plastic to avoid contamination.

Well casing and screen will be decontaminated using the following decontamination procedures:

1. Sand off all printing inks on the surface of the casing and screen.
2. Steam clean with a pressure washer using tap water and laboratory detergent to remove particulate matter and surface films.
3. Pressure rinse with tap water.
4. Rinse thoroughly with deionized water.

5. Rinse twice with pesticide-grade isopropanol.
6. Rinse thoroughly with organic-free water and allow to air dry.
7. Wrap with aluminum foil or polysheeting to prevent contamination.

Field personnel will don a new pair of disposable nitrile gloves before the handling of sampling equipment for decontamination.

## 6.0 SAMPLE MANAGEMENT

Sample management will consist of sample labelling, chain-of-custody seals and records, and associated field documentation procedures. The purpose of these procedures will be to ensure the quality of the samples are maintained during their collection, transportation, storage and through analysis to the final data deliverables. All sample management documentation and sample handling protocols have been developed using, as guidance, the EPA Region IV-Environmental Compliance Branch *Standard Operating Procedures and Quality Assurance Manual*, (February 1, 1991) and are discussed below.

### Sample Identification Documents:

- Sample label
- Custody seals
- Chain-of-custody records
- Field notebooks
- Corrective Action Documentation

### 6.1 Sample Labelling

Sample container labels, as shown in Figure 6-1, will be required for identifying each submitted sample. Sample label information will include the site name, sample identification, preservation, required analysis, date of collection with time and the sampler's name. Each label must be printed in a legible manner using waterproof black ink.

Table 6-1 outlines the sample designation system to be used to identify each sample. Should additional sample designations be required, this table will be amended. Additional sampling information including date and time of collection will be provided on the chain of custody (COC).

Figure 6-1      Sample Bottle Labels

Table 6-1 Sample Designation System			
Location	Sample Type	QA Sample Type	Sample Location and Depth
CC = Carrier, Collierville Site	GW = Groundwater S = Soil SD = Sediment BHG = Borehole Vapor Samples IN = Influent EF = Effluent OG = SVE Off Gas SV = Soil-vapor	RB = Rinsate Blank FB = Field Blank TB = Trip Blank DP = Duplicate MS = Matrix Spike MSD = Matrix Spike Duplicate	B = Boring MW = Monitoring Well HA = Hand Auger Boring MP = SVE Monitoring Probe SVW = SVE Well SVE = SVE System GWT = Groundwater Treatment System

**Note:** Sampling depth or location is based upon a numeric system (ex. sampling interval depth, sampling point along a treatment train)

**Examples:**

Water Matrix — CC GW MW2 = Carrier Collierville groundwater sample from well 2  
Solid Matrix — CC S B1 = Carrier Collierville soils from boring 1  
Air Matrix — CC OG SVE1 = Carrier Collierville off gas from SVE system at location 1

## 6.2 Custody Seals

Sample custody seals, shown in Figure 6-2, will be used to ensure that samples are not tampered with during transportation. Custody seals are placed on the shipping containers (and on the samples themselves) in a manner such that the containers cannot be opened without breaking the seal.

## 6.3 Chain-of-Custody

Chain-of-custody forms, as shown in Figure 6-3, will be fully completed by field personnel and shall accompany the samples during shipment. The form shall contain pertinent information regarding the samples, such as the sampler's name, sample identification, date and time of collection, and description of the cooler's contents (number of sample containers). In addition, information to be relayed to the laboratory shall be written in the "Remarks" section of the chain-of-custody, e.g. a sample accompanied with this chain-of-custody requires quicker attention for analysis. For chain-of-custody purposes, all QC samples are subject to exactly the same custodial procedures and documentation as real samples.

Upon transfer of custody, the chain-of-custody form will be signed by an EnSafe representative, who also notes the date and time. Because common carriers will not sign chain-of-custody forms, the chain-of-custody records will be sealed within each cooler. All chain-of-custody

**Figure 6-2    Sample Seals**

**Figure 6-3 Chain-of-Custody Forms**

forms received by the laboratory must be signed and dated by the laboratory sample custodian and returned to EnSafe following receipt or as part of the data reporting package.

#### **6.4 Daily Logs (Field Log)**

All samples will be documented in accordance with the EPA SOP/QAM, Chapter 3 - Sample Control, Field Records and Document Control. Sampling personnel will use bound, ruled or gridded logbooks with sequentially numbered waterproof pages for activity documentation pertaining to the project. These logbooks will be the master reference for all site activities and accomplishments. These records will also document all visual observations, calculations and equipment calibrations. The logbooks are accountable documents that will be properly maintained and retained as part of the project files.

Each logbook will have labeled on the front cover as follows:

Site name (Carrier Site RD, Collierville, TN)

EnSafe

Sampler's name

Book number (sequentially numbered by distribution or as assigned by the QAO)

Starting and completion dates

The logbook must be labeled with indelible black ink. The following steps shall be followed when making entries into the field logbook:

- Enter the date and time the task begins, weather conditions, and the names and titles of individuals involved in the task. When possible, include the names and titles of personnel visiting the task area.
- Describe all activities in detail and list which forms were used to record such information (e.g. boring logs, field change request forms). It is considered good practice to duplicate the most important information throughout the field logbooks.



Examples of some pertinent information for specific activities are as follows:

- Well installation activities: document the elevations, reference elevations, total depth, size and length of casing and screen, casing and screen material, screen-slot size, drilling conditions and rate and details on the soil lithology. Include any calculations, for example in determining well volumes.
- Installation of soil boring activities: document the size and depth, sampling equipment used and methods used, details on the soil lithology and the samples collected.
- Levels of PPE worn by the sampling team. If the PPE levels are changed for any reason, state the change in protection and the reasons for the change.
- Describe in detail any field tests that were conducted (e.g. PID/OVA measurements) and reference any forms or data records used. Document the results, if obtainable in the field.
- Describe in detail how the samples were collected or how the blanks/duplicates were prepared. List all label information, sample containers and volume, preservation, packaging, chain-of-custody form number and analytical parameters applicable to each sample. Also, note the time of transfer, and if possible the name of the individual to whom custody was transferred.
- List the equipment type, serial or identification number, time and procedures used, calibration records or logs used, and equipment failures or breakdowns that occurred. Also, include the changes, repairs and results of the equipment failure or breakdown.

## 6.5 Corrections to Documentation

**Notebooks** — As with any data logbooks, no pages may be removed for any reason. If corrections are necessary, these must be made by drawing a single line through the original entry (so that the original entry can still be read) and writing the corrected entry alongside. The correction must be initialed and dated. Some corrected errors will require a footnote explaining the correction. Corrections to errors shall be made by the individual responsible for the entries in the field logbook.

**Sampling Forms** — As previously stated, all sample identification tags, chain-of-custody records, and other forms must be written in indelible black ink. None of these documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made on a document, the individual responsible for preparation of the document may make corrections by crossing a single line through the error and entering the corrected information. Any subsequent errors discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

#### **6.6 Corrective Action**

During the course of any investigation, field personnel are responsible for seeing that field instruments and equipment are functioning properly and that work progresses satisfactorily. The field personnel are also responsible for ensuring performance of routine preventive maintenance and quality control procedures. If a problem is detected by field personnel, the project manager shall be notified immediately. Similarly, if a problem is identified during a routine audit by the project QA officer or the regulatory QA officer an immediate investigation will be undertaken and corrective action deemed necessary will be taken as early as possible.

#### **6.7 Out-of-Control Situations**

Potentially out-of-control situations include field instrument breakdown, mislabelling or loss of samples, inadvertent contamination of samples, or circumstances which preclude performance of field activities in accordance with the QAP (or other work plan documents). If an out-of-control event occurs, field sampling personnel shall make appropriate contacts and document any remedial efforts taken to bring field activities under control. The immediate contacts shall be the EnSafe project manager and/or the EnSafe QA officer. The EnSafe project manager shall decide whether further contacts are to be made to Carrier, EPA or the TDEC. Formal documentation of out-of-control occurrences and any associated corrective actions recommended or initiated shall be written on the EnSafe Field Change Request Forms. Field personnel shall also record out-of-control occurrence in the field logbooks.

All variances or changes from project QAP are subject to approval by the EPA remedial project manager (RPM) and the TDEC representative. If circumstances arise which require significant changes in the protocols, methods, or techniques outlined in the work plan and/or the QAP, the

EPA RPM and/or the TDEC project manager may be contacted. Any EPA or TDEC alterations will be documented and implemented with the agencies written consent.

## 7.0 CALIBRATION PROCEDURES AND FREQUENCY

EnSafe personnel will calibrate all field instrumentation in accordance with manufacturer's recommendations. All equipment calibration and/or standardization procedures will be recorded in the field logbook and equipment logs. Calibration records will be maintained at the home office in Memphis, Tennessee.

Records shall include the source of the field standards with lot numbers and expiration dates, and a brief description of the procedures used. When necessary, procedures will be recorded step-by-step into the records. Field equipment calibration is summarized in Table 7-1.

Table 7-1 Field Equipment Calibration		
Equipment/Measurement	Calibration Method	Frequency
pH	2 standard solutions	daily
Temperature	Compared to NBS certified thermometer	quarterly
Combustible Gas/PID	standard gas	daily/each use
Conductivity/pH/Temperature Meter	2 or 3 standard solutions (function specific)	weekly, daily if necessary
Humidity/Temperature Meter	field calibrator	quarterly

## 8.0 PREVENTIVE MAINTENANCE

Sampling equipment which may require preventive maintenance will be checked for proper operation before and after use on a daily basis. Any replacements of parts or repairs will be in accordance to the manufacturer's operations manual or the parts will be sent to the manufacturer for repairs. Records of calibration and maintenance activities for each piece of equipment are contained in logbooks assigned to the equipment. The preventive maintenance program for all laboratory equipment will be handled solely by the laboratory's personnel in accordance with the laboratory's Quality Assurance Plan. Equipment or instruments potentially requiring preventive maintenance are listed in Table 8-1.

Table 8-1 Field Testing Equipment			
Item	Manufacturer	Model #	Serial #
Conductivity Meter	Myron L	pDS	0460222E
pH Meter	Fisher	Accumet 956	3218
Photoionization Detectors	Photovac	TIP II	2580147
	HNu	PI 101	—

**Note:** The actual make and model of each above instrument may be substituted by a similar model.

Preventative maintenance procedures for sampling equipment which are routinely serviced are described below.

### Conductivity Meters

**Weekly:** Meter probes are cleaned before and after each use with distilled/deionized water. Weekly, the instruments are checked with a commercial conductivity standard for proper calibration. The battery is checked for proper charge.

**Quarterly:** The instrument is inspected on a quarterly basis, whether used during the quarter or not. The inspection consists of a general examination of the electrical system (including batteries) and a calibration check. Instruments not functioning properly are shipped to the manufacturer for repair and calibration.

### **pH Meters**

- Weekly:** The probe shall be checked for cracks in the electrode bulb and completely filled with electrolyte solution. At the beginning and end of any sampling day, the pH meter must be calibrated using standard pH buffers of an acceptable range (4.0-7.0 or 7.0-10.0). The battery is checked for proper charge. Following each measurement, the probe is rinsed with deionized water. The probe cap is filled with electrolyte solution and placed on the probe tip. Excess electrolyte is rinsed off and the probe dried with a paper towel. The instrument is then placed in its carrying case.
- Quarterly:** The instrument is inspected on a quarterly basis whether or not it has been used. The inspection consists of a general examination of the probe, wire, electrical system (battery check) and a calibration check. Any malfunctioning equipment is returned to the manufacturer for repair and recalibration.

### **Thermometers**

- Weekly:** Before each use, thermometers are visually checked for cracks and mercury separation. After use, thermometers are rinsed with deionized or distilled water and placed in their protective case to prevent breakage.
- Monthly:** Thermometers are visually inspected as described above, whether used or not. They are checked against an NBS-certified thermometer for accuracy.

### **Photoionization Detectors**

- Each use:** The TIP II and HNu are zeroed and calibrated using TCE span gas for the TIP II and isobutylene (benzene mimic) for the HNu, at a minimum of before and after each sampling day. Also, to be checked after each use will be the battery for a proper charge, cleanliness of the UV lamp window and the dust filters.

Quarterly: The instrument is inspected quarterly whether or not it has been used. The instrument bulb will be cleaned monthly or more frequently as needed. The inspection consists of a general examination of the probe, wires, electrical system (esp. battery check) and a calibration check. Any malfunctioning equipment is returned to the manufacturer for repair and recalibration.

**APPENDIX D**  
**QUALITY ASSURANCE PROJECT PLAN**



## Table of Contents

1.0	INTRODUCTION .....	D-1
2.0	PROJECT BACKGROUND AND DESCRIPTION .....	D-2
3.0	PROJECT ORGANIZATION AND REPORTING .....	D-3
3.1	Oversight .....	D-3
3.2	Investigation Performance .....	D-3
3.3	Deliverables .....	D-5
4.0	PROJECT QUALITY ASSURANCE OBJECTIVES .....	D-6
4.1	Project Data Quality Objectives .....	D-6
4.2	Field Measurements .....	D-6
4.3	Sampling and Analysis for Contamination Levels .....	D-7
5.0	SAMPLING ACTIVITIES .....	D-8
5.1	Soils Treatability Study .....	D-8
5.2	SVE Boring and Well Installation .....	D-9
5.3	Groundwater Well Installation .....	D-10
5.4	Well Abandonment .....	D-13
5.5	Equipment Decontamination .....	D-13
5.6	Sample Preservation, Handling, and Shipping .....	D-15
5.7	Quality Control Samples .....	D-16
5.8	Analytical Parameters and Approach .....	D-16
6.0	SAMPLE CUSTODY .....	D-19
6.1	Sample Labels .....	D-19
6.2	Custody Seals .....	D-21
6.3	Chain-of-Custody .....	D-21
6.4	Field Logs .....	D-24
6.5	Corrections to Documentation .....	D-26
7.0	CALIBRATION PROCEDURES AND FREQUENCY .....	D-27
8.0	PREVENTIVE MAINTENANCE .....	D-28

9.0	DATA REDUCTION, VALIDATION, AND REPORTING . . . . .	D-31
9.1	Data Management . . . . .	D-31
9.2	Data Validation . . . . .	D-31
10.0	INTERNAL QUALITY CONTROL CHECKS . . . . .	D-33
11.0	PERFORMANCE AND SYSTEM AUDITS . . . . .	D-36
11.1	Field System Audits . . . . .	D-36
11.2	Laboratory Systems Audit . . . . .	D-36
11.3	Performance Evaluation Audits . . . . .	D-36
11.4	Regulatory Audits . . . . .	D-37
12.0	PROCEDURES TO ASSESS DATA ACCURACY, PRECISION, AND COMPLETENESS . . . . .	D-38
12.1	Accuracy . . . . .	D-38
12.2	Precision . . . . .	D-38
12.3	Completeness . . . . .	D-39
12.4	Quality Control Charts . . . . .	D-39
13.0	CORRECTIVE ACTION . . . . .	D-41
14.0	QUALITY ASSURANCE REPORTS TO MANAGEMENT . . . . .	D-42
15.0	PERSONNEL QUALIFICATIONS AND RESUMES . . . . .	D-44

### List of Figures

Figure 3-1	Organizational Chart . . . . .	D-4
Figure 6-1	Sample Bottle Labels . . . . .	D-20
Figure 6-2	Custody Seals . . . . .	D-22
Figure 6-3	Chain-of-Custody Forms . . . . .	D-23

## **List of Tables**

Table 4-1	
Summary of Data Quality Objective, Design Phase . . . . .	D-6
Table 4-2	
QA Objectives of Field Measurements . . . . .	D-6
Table 5-1	
Quality Control Sample Collection Frequencies . . . . .	D-16
Table 6-1	
Sample Designation System . . . . .	D-21
Table 7-1	
Field Equipment Calibration . . . . .	D-27
Table 8-1	
Field Testing Equipment . . . . .	D-28
Table 10-1: CLP TCL-VOC Quality Objectives . . . . .	D-34
Table 10-2: CLP Metals Analyses Data QA Objectives	
Matrix Spikes/Duplicate Analyses . . . . .	D-34

## **List of Attachments**

Attachment A	Analytical Methods
Attachment B	USEPA SOP QAM Excerpts
Attachment C	Reserved for the soil Gas Subcontractor Standard Operating Procedures
Attachment D	Reserved for the Selected Analytical laboratory's Quality Assurance Plan
Attachment E	EnSafe Data Validation Worksheets
Attachment F	EnSafe Project Personnel Resumés

## **1.0 INTRODUCTION**

This QAPP presents specific policies, project organization and objectives, functional activities, and quality assurance and quality control measures intended to achieve data quality goals for Remedial Design at the Carrier site in Collierville, Tennessee. The QAPP is intended to satisfy the requirements of the USEPA for assuring and documenting the quality of environmental monitoring and measurement data. The goals described within this document have been established to meet project-specific data quality objectives.

The objectives of remedial design activities are:

- To perform a soils treatability study to gather information needed to design a full-scale soils remediation system capable of achieving remedial goals
- To design and implement a groundwater monitoring program to assess the performance of the existing Memphis Sand groundwater extraction system.
- To assess alternative actions to be taken if groundwater monitoring indicates changes to the groundwater remediation systems are necessary to achieve remedial goals.

## **2.0 PROJECT BACKGROUND AND DESCRIPTION**

This project is being carried out under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the Superfund Amendments and Reauthorization Act of 1986. The work plan is based upon the findings of the Remedial Investigation and decisions regarding remedial actions that were presented by the USEPA in a Record of Decision.

A history and description of the site can be found in Section 2 of the RD work plan.

### **3.0 PROJECT ORGANIZATION AND REPORTING**

The Declaration for the Record of Decision presents Carrier Air Conditioning (Carrier), in Collierville, Tennessee, as the respondent for remedial action to the site. Carrier has designated Nelson Wong, P.E. as the Carrier coordinator pursuant to the ROD and has delegated EnSafe as the prime contractor with regard to the site.

#### **3.1 Oversight**

Project oversight will be the responsibility of the USEPA in Region IV. The USEPA remedial project manager for this project is Beth Brown. Jordan English will be the Tennessee Department of Environment & Conservation state project manager for the site.

#### **3.2 Investigation Performance**

EnSafe will serve as the prime engineering subcontractor for the Carrier Air Conditioning Site RD/RA. As the engineering subcontractor, EnSafe is responsible for designing, implementing and coordinating all project RD activities. The organizational structure for the design phase of this project is presented in Figure 3-1.

The Project Manager for this project is Philip G. Coop, CHMM. As the Project Manager, Mr. Coop will be responsible for the technical, financial, and scheduling aspects of the project.

The Site Manager for this project is Craig A. Wise. The Site Manager (or designated representative) will be responsible for all field operations and will remain onsite during the field activities. The Site Manager is also responsible for the production of projects work plans and reports. While onsite, the Site Manager will serve as the point of contact for all site activities and will report directly to the Project Manager.

The project Quality Assurance Officer (QAO) for this project is Andrew C. Kim. The QAO is responsible for ensuring that the procedures outlined in the QAPP are employed. The QAO operates independently of the Site Manager in the review of procedures and documentation. The QAO will also have the authority to recommend, implement, and halt project activities as deemed necessary. In most cases when nonconformances are identified, the QAO will evaluate the problem, generate a solution, document all pertinent information and report the nonconformance to the Site Manager and/or the Project Manager).

Figure 3-1    Organizational Chart

The Health and Safety Officer (HSO) for this project is John H. Borowski. In general, the HSO is responsible for the development and implementation of the project Health and Safety Plan (HASP). The HSO customarily works with the other appropriate state/local/federal agencies in implementing the requirements of the HASP.

### **3.3 Deliverables**

Project deliverables are detailed in Section 3.3 of the RD work plan.



## 4.0 PROJECT QUALITY ASSURANCE OBJECTIVES

In general, quality assurance (QA) objectives of this project are to assess and document the precision, accuracy, representiveness, completeness, and comparability of all sampling and analysis performed. Quality control (QC) is established herein to assure suitability of the data for the intended use and to meet the established goals for the project in compliance with the USEPA. The following discusses project-specific levels of effort of QA/QC and data quality objectives.

### 4.1 Project Data Quality Objectives

Data quality objectives for the design phase have been developed based upon the proposed data end uses. Table 4-1 summarizes the data quality objectives.

Table 4-1 Summary of Data Quality Objective, Design Phase		
Sample Type	Sampled Medium	Data End Use
Soil	TCE Leak and Spill Area	To assess the status of TCE content in the area soils for use in design.
Water	Groundwater Treatment	To assess the effectiveness of the groundwater treatment system.
Soil Gas	TCE Leak and Spill Area	To assess the contaminant loading rates during remediation and for use in design.

### 4.2 Field Measurements

QA objectives for field measurement parameters are presented in Table 4-2.

Table 4-2 QA Objectives of Field Measurements					
Parameter	Reference	Matrix	Precision	Accuracy	Completeness
pH	EPA Method 150.1*	Water	± 0.5 pH	± 0.2 pH	95%
Specific Conductance	EPA Method 120.1*	Water	± 10%	± 2%	95%
Temperature	EPA Method 170.1*	Water	± 1°C	± 0.2°C	95%
Photoionization Detector/HNu	Manufacturer SOPs <sup>b</sup>	Air	± 10 ppm	± 20 ppm	90%

**Notes:** \*Methods for Chemical Analysis of Water and Wastes, EPA-600/4/79-020 Revised March 1983.

<sup>b</sup>Manufacturer SOPs will be used for operations, calibrations, and analysis.

#### 4.3 Sampling and Analysis for Contamination Levels

The QA objectives for the analytical parameters to be used in this project will be categorized by the analytical method in use. The first, a screening level method, will be performed on the soil samples collected from the SVE well borings. Primarily, these soil samples will be collected to assess the level of TCE concentrations encountered and will be used in the MPA SVE treatability study. The analytical method will be one devised by Woodson-Tenent Laboratories, Memphis, Tennessee. A copy of the method is presented in Attachment A to this plan.

Other analyses utilized will include the USEPA Contract Laboratory Program *Statement of Work for Inorganics Analysis (February 1990)* for the analysis of metals, the Contract Laboratory Program *Statement of Work for Organic Analysis (February 1990 & October 1992)* for the analysis of volatile organic compounds (VOCs), ASTM Method D 2434-68 Permeability of Granular Soils for vertical hydraulic conductivity, and the analysis for organic humic acid and fulvic acid by a method which is derived from the *American Society of Agronomy (ASA)*, Method of Soils Analysis, Part 2. The analytical method of the humic acid and fulvic acid tests is also presented in Attachment A.

## 5.0 SAMPLING ACTIVITIES

The general sampling procedures that EnSafe will follow are described in the Field Sampling Activities Plan (FSAP) for this project. Sample media and methods of collection are summarized in the following subsections. The USEPA Region IV-Environmental Compliance Branch, *Standard Operating Procedures and Quality Assurance Manual*, February 1991 (USEPA SOP QAM) was used as the procedural basis for the sampling methods employed. Where appropriate, excerpts from the USEPA SOP QAM for specific field measurement techniques have been provided in Attachment B to this plan.

### 5.1 Soils Treatability Study

The vadose zone soils in selected areas are known to contain TCE which, at its current concentration, is contributing unacceptable levels of on-going contamination to the Memphis Sand aquifer. As stated in the ROD, soils within these source areas will be remediated using SVE techniques.

A SVE pilot study will be performed in the TCE spill and leak areas during remedial design. The pilot study will include a series of SVE parameter evaluation tests (PETs) and point permeability tests (PPTs). To perform these tests, a network of SVE wells and monitoring probes will be installed. During installation of the wells and probes and throughout the SVE pilot study, soil samples will be collected and screened for TCE concentrations. The data quality objectives will be as described below.

#### Data Quality Objectives:

- To utilize analytical methods capable of detecting confirmed site constituents at levels equal to or below soil cleanup criteria for the site.
- To yield reproducible data that may be used as a basis of comparison with historical and future sampling data.
- To detect and confirm target contaminants
- To obtain data, such as soil permeability, soil pressure thresholds, off-gas concentrations, and soil gas concentrations, useful in aiding in full-scale design.

The sampling and analysis activities to be performed at the site are summarized in the following subsections.

### **5.1.1 Soil Gas Screening**

An SVE field pilot study will be performed onsite to aid in the full scale design. A minimum of three wells will be bored for soil gas screening at various locations as part of the pilot test activities. Soil gas samples will be drawn from each vapor probe location (or well boring) prior to the performance of the SVE PETs and PPTs. The PETs will evaluate the chemical and physical characteristics of the site soils. The soil vapor samples will be analyzed for total VOCs using either an HNu model photoionization detector (PID) or an organic vapor monitor (OVM).

Soil gas analysis will be performed in accordance with the standard operating procedures (SOP) of the selected soil gas subcontractor, which will be appended to this QAPP as Attachment C after subcontractor selection.

### **5.1.2 Probe Installation**

If possible, soil-vapor probes will be advanced using a hydraulically driven 1-inch steel pipe. If a hydraulic rig cannot install probes to their required depth, probes will be installed as described in well installation.

Soil-vapor probes will be converted from borings using 1-inch inner diameter Schedule 40 PVC screen and riser pipe. A medium to coarse-grain filter pack will be installed around the screen interval with a 1-2' bentonite seal on top of the sand pack. The remaining annulus above the bentonite seal will be filled with a cement/bentonite grout.

## **5.2 SVE Boring and Well Installation**

Borings will be advanced using 4.25" ID hollow-stem augers with split-spoon samples collected continuously to assess stratigraphy. Soil samples for laboratory analysis will be collected during well installation beginning 5 feet below ground surface and at 10-foot intervals thereafter until boring termination. Collection will be made using split-spoon samplers.

Borings will be converted to wells using 2" ID Schedule 40 PVC Pipe. The screen intervals for the wells will be determined in the field based upon FID/PID results and soil strata. In general, screens will be set at depths of higher VOC concentration and more permeable strata. Shallow screens will be set within the shallow silty soils, while deep wells will be set in the deeper sandy soils.

A medium to coarse-grained filter pack will be installed around the screen interval with a 1 to 2-foot bentonite seal on top of the sand pack. The bentonite seal will be allowed to hydrate at least 24 hours before cement/bentonite grout is used to fill the remaining annular space.

### **Soil Sampling and Analysis**

Samples collected for laboratory analysis will be submitted for laboratory screening for TCE by the Woodson-Tenent co-distillation method, which was approved by the USEPA during the RI at this site. A minimum of two soil samples collected during drilling activities will also be submitted for humic and fulvic acid analysis. Samples not intended for lab analysis will be extracted and screened for relative VOC concentrations using a flame or photoionization detector.

A new pair of disposable gloves will be donned by the sample between each soil sample collected. Contents of the unused liners, as well as all auger spoils, will be containerized in 55-gallon drums for subsequent onsite treatment.

### **5.3 Groundwater Well Installation**

A cluster of three monitoring wells are to be installed and screened in the Memphis Sands downgradient of Water Plant 2 outside of immediate capture zone. The wells will be installed to depths of approximately 420, 320, and 220 feet through the Jackson Clay formation and into the Memphis Sand Aquifer. Prior to drilling through the Jackson Clay, a section of 10-inch ID, steel casing will be set from the ground surface to 10 feet below the top of the Jackson Clay. The casing will then be grouted in place using a lean cement-sand grout mixture. Grout will be allowed to set a minimum of 16 hours prior to advancing the boring. The well boring will then be advanced through the casing using a mud-rotary technique to termination.

#### **Well Casing and Screen Installation**

A 4-inch ID Schedule 40 PVC casing is placed in the borehole. Well screens will be 0.01-inch slotted Schedule 40 PVC screen and will be located by a geophysical log of the borehole. A 20/40-graded environmental filter pack material will be emplaced into the annular space and extended to approximately 2 feet above each screened interval. Solid casing intervals will be backfilled with a high solids bentonite mud grout, mixed to about 10.2 pounds/gallon.

## **Drilling Muds**

Drilling muds used during well installation will consist of potable water and a 3% solids or less drilling mud. Drilling muds will be sampled for quality assurance purposes and analyzed for the corresponding suite of confirmed site constituents during the investigation. These results will be presented in the remedial design report as part of the data validation and quality assurance discussion.

### **5.3.1 Well Development**

The well will set at least 24 hours after grouting before initiating the development procedures. Each monitoring well will be developed until temperature, pH, and specific conductivity have stabilized.

Static groundwater levels and the total depth of the well will be measured immediately and again 24 hours following development. Depth to water will be measured using a decontaminated electronic water level indicator accurate to one one-hundredth of a foot. Well depth will be measured using a decontaminated weighted steel tape with an accuracy of at least one-tenth of a foot. All readings will be made at a clearly marked reference point at the top of each well casing. Each well reference point will be surveyed to a common datum and/or mean sea level to allow construction of a groundwater surface contour map.

### **5.3.2 Groundwater Sampling Procedures**

Groundwater samples will be collected for VOC (CLP 3/90 or 10/92 Method) and Inorganics (CLP 3/90 for Lead and Zinc, only) analysis periodically beginning within one week after well construction, unless otherwise specified by the USEPA.

#### **Monitoring Well Sampling Procedures:**

- Place a clean plastic or aluminum foil sheet around the wellhead to provide an area where equipment can be placed temporarily without risk of contamination.
- Don a new pair of disposable nitrile gloves. Disposable gloves will be worn whenever the sampler handles samples and/or sampling equipment.

- Measure static well water level with an electronic water level meter and record the depth in the project field logbook. All water level measuring devices must be accurate to within one-tenth of a foot or better.
- Measure the depth of the well with a pre-cleaned weighted steel tape.
- Purge at least three well volumes of water using a pre-cleaned submersible pump and Teflon tubing. The pump should be positioned within the upper few feet of the water column to achieve thorough purging. Purged waters will be retained onsite until the regulatory status of the water is determined.

The volume of water in the well casing will be calculated as follows:

$$\text{Volume} = ( A - B ) \times ( C )$$

Where:

V	=	represents the volume in gallons
A	=	represents the total well depth
B	=	represents the depth to water level, and
C	=	equals 0.17 for 2" wells or 0.66 for 4" wells

After each purged volume, pH, temperature, and conductivity will be monitored for stabilization. Field measurements will be considered stabilized according to USEPA's Environmental Compliance Branch, *Standard Operating Procedures and Quality Assurance Manual*, Section 6.3—Specific Quality Control Procedures.

- **Stabilization Criteria**

Temperature	—	within $\pm 1.0^{\circ}\text{C}$
pH	—	within $\pm 0.5$ standard unit
Conductivity	—	within $\pm 10\%$ from the duplicate

If stabilization has not occurred after three well volumes have been purged, additional water will be purged until readings stabilize. The maximum allowable time between purging and sampling is six hours. If the well has not recovered sufficiently after this time, the well will not be sampled.

- **VOC Sampling:**

VOC samples will be analyzed according to EPA Method 624.

Samples for VOC analysis will be collected in clean, pre-preserved (HCL to lower pH below 2), 40-ml vials with Teflon-lined septum lids. A check will be made to ensure that no air bubbles are visible. If air bubbles are visible, the sample will be discarded and the sampling procedure repeated.

**Inorganics Sampling:**

Samples for inorganics analysis will be poured into 1-liter polyethylene or glass jars. HNO<sub>3</sub> (nitric acid) will then be added to lower sample pH of below 2. Proper preservation can be checked by pouring a small amount of the sample into a clean cup and checking it with pH paper.

- Samples will then be placed in a cooler containing ice and water placed in sealable plastic bags, or blue ice, to provide temperature preservation at 4°C. Coolers will be shipped overnight to the laboratory at the end of each work day. All samples to be shipped for analysis will be delivered to the laboratory within 24 hours of collection.

#### **5.4 Well Abandonment**

When the decision to abandon a well has been made, the borehole shall be sealed in such a manner such that the well could not possibly become a conduit of contaminant migration. In general, the soil borings will be abandoned by pressure grouting or tremie piping a mixture of Portland cement with 5 percent bentonite pellets into the boring. The grout will be placed starting from the boring terminus and proceeding to the ground surface.

#### **5.5 Equipment Decontamination**



The drill rig will be steam cleaned and wire brushed before being brought onsite. The drill rig will then be inspected to ensure there is no leakage of oil, grease, hydraulic fluid, etc. Drilling equipment will be decontaminated between drilling of each boring using the decontamination procedures listed below.

1. Decontamination of equipment will be performed on the onsite decontamination pad.
2. Steam clean with a pressure washer using tap water and laboratory detergent to remove particulate matter and surface films.
3. Pressure rinse with tap water.
4. Rinse thoroughly with deionized water.
5. Rinse twice with pesticide-grade isopropanol.
6. Rinse thoroughly with organic-free water and allow to air dry.
7. Wrap with aluminum foil or polysheeting to prevent contamination.

All non-dedicated stainless steel sampling equipment and the split spoon samplers will be decontaminated between samples using the decontamination procedures listed below.

1. Equipment will be washed thoroughly with laboratory detergent (i.e. Liquinox) and followed by a hot water rinse using a brush to remove any particulate matter or surface film.
2. Equipment will be rinsed with potable water to remove any remaining detergent.
3. Following the potable water rinse, the equipment will be rinsed with deionized water.
4. Rinse twice with pesticide-grade isopropanol.

5. Rinse with organic-free water and air dry.
6. Sampling equipment will be wrapped in aluminum foil until ready for use. Non-sampling equipment may be wrapped in plastic to avoid contamination.

Field personnel will don a new pair of disposable gloves before handling sampling equipment for decontamination and between contact with each piece of sampling equipment. Gloves will also be donned before use of any equipment for sampling. Disposable gloves, as well as other disposable personnel protective equipment, will be properly disposed of in a manner to prevent contamination of samples and equipment.

#### **5.6 Sample Preservation, Handling, and Shipping**

**Soil samples** to be shipped for analysis will be containerized in glass containers with Teflon-lined septum lids. Each container will be sealed immediately to prevent loss of any volatile compounds. A note regarding any insufficiently obtained sample volumes should be recorded in the project field logbook. Any observations on the soil geology and sampling conditions will also be recorded in the field logbook.

**Water samples** to be analyzed for VOCs will be placed in a minimum of three 40 ml VOA vials with Teflon-lined septum. Water samples to be analyzed for inorganics analysis will be contained in 1-liter polyethylene or glass jars and preserved with nitric acid ( $\text{HNO}_3$ ) to a pH of less than 2. Proper preservation can be checked by pouring a small amount of the sample into a clean cup and checking it with pH paper.

Each sample shall be placed in a separate sealable plastic bags and placed inside a cooler chilled to 4°C. The cooler will contain either wet ice placed in sealed plastic bags (preferred) or blue ice. Samples will be handled as infrequently as possible and care will be taken to ensure that samples are not contaminated or damaged. All samples to be shipped for analysis will be delivered to the laboratory within 24 hours after time of collection.

Strict custody procedures will be followed so that each step in the sampling process is documented. This process will be implemented by the field sampling team and carried out for the duration of the entire sampling program.

## 5.7 Quality Control Samples

The project data precision will be assessed by evaluating the results of the duplicate and matrix spike duplicate samples. Accuracy will be assessed by evaluating the analyses of the field blanks, trip blanks, laboratory matrix and surrogate spikes, and laboratory reagent blanks and blank spike samples. This project will utilize the blank frequencies outlined in Table 5-1.

Table 5-1 Quality Control Sample Collection Frequencies		
Quality Control Sample	Frequency of Collection	Additional Sample Volumes Required
Trip Blank (volatiles only)	One per sample shipping cooler containing samples to be analyzed for volatiles	3x40 ml. VOA vials with Teflon-lined septa
Rinsate Blank	Collected every day or every ten samples, but only analyzed every other day	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals analysis
Material Blank	One blank sample of any non-packaged material used for SVE/Monitoring Well completion	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals analysis
Field Blank	One per sampling event or every ten samples	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals analysis
Duplicates	One per 10 samples per matrix	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals analysis
Matrix Spike/Matrix Spike Duplicate Samples	One per 20 samples per matrix; matrix may be the same sample used for duplicate analysis	3x40 ml. VOA vials for VOCs and 1 liter P,G jar for metals analysis*

**Notes:**

\* — Matrix spike/matrix spike duplicate requirements are slightly different for the inorganics analysis. The inorganics analysis will only have one sample to spike, no duplicate spike sample will be necessary.

P,G — Polyethylene or Glass

## 5.8 Analytical Parameters and Approach

One of the analytical laboratories for this project will be Woodson-Tenent Laboratories in Memphis, Tennessee. Woodson-Tenent will be primarily responsible for the screening analysis of soils for TCE concentrations. Other analytical parameters will be submitted to a separate qualified analytical laboratory upon selection. The analytical methods and the approach to be applied to the project media are outlined as follows:

1. As already mentioned, the TCE screening will be performed by Woodson-Tenent Laboratories. The actual number of samples will be determined in the field by the number of SVE borings installed. One sample is to be collected at each 10-foot interval. Each boring is estimated to produce five to six soil samples for TCE screening, based on the known depth to the water table. The analytical method is unique and is presented in Attachment A. The method has already been reviewed and approved for use by the USEPA during previous activities at the Carrier site.
2. A minimum of 2 soil samples will be tested for humic and fulvic acid contents. Since the two acids are not commonly noted to be environmental contaminants, the chosen method is from the *American Society of Agronomy*, Method of Soils Analysis, Part 2. This analytical work will be subcontracted to a qualified laboratory familiar with the ASA.
3. Groundwater samples will be analyzed for VOCs and inorganic analytes in accordance with the USEPA Contract Laboratory Program's *Statement of Work for Organic and Inorganic Analysis*, (3/90 & 10/92). The 10/92 SOW, a recent edition, will be used for the low concentration analysis of volatile compounds. Groundwater samples will be screened when they are received by the analytical laboratory to determine which SOW is to be applied. The general guideline in selecting the appropriate SOW will be defined by a limit of 25 to 35  $\mu\text{g/L}$ . The advantage of the 10/92 SOW is that it provides highly quantitative results at lower detection limits. Currently, the 3/90 SOW provides results with detection limits of 10  $\mu\text{g/L}$  in water, whereas the 10/92 SOW can accurately detect to a limit of 1  $\mu\text{g/L}$  in water.

#### 5.8.1 Analytical Laboratories

The selected analytical laboratory will be employed by EnSafe and will adhere to all applicable USEPA QA and method requirements. The laboratories will be required to prepare and submit a laboratory QAP (Attachment D), to analyze and submit the results of proficiency evaluation samples, to submit to an onsite inspection (by all project involved agencies including EnSafe), and to correct any deficiencies cited during the inspection. The laboratories are required to designate a laboratory QA coordinator (LQAC) responsible for overall QA/QC. The LQACs must not be responsible for items such as schedule, costs, or personnel other than laboratory QA staff. It is preferred that the LQACs report to the laboratory director. It is important that the

LQACs have the authority to cease work on projects if QC problems arise that may affect the quality of the data produced.

In addition to conforming to all USEPA QA and method requirements, work shall be performed in a manner consistent with the following environmental guidelines and regulations.

**Guidelines and Regulations**

- The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended,
- The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Title 40 of the Code of Federal Regulations (CFR), Part 300, as amended, and
- All other state and local guidelines, rules and regulations applicable for analytical laboratories.

**5.8.2 Procurement of Other Subcontractors**

The employment and responsibility for other subcontractors (other than the analytical laboratory) will be accomplished through a services agreement. The contract will specify the scope of services to be performed by the subcontractor, the specific level of QA requirements to be expected, and the information to be developed and reported, as necessary. The maintenance of the subcontractor's compliance with the appropriate project requirements and elements specified in the scope of services will be regulated by the EnSafe project manager (or designated representative).

## 6.0 SAMPLE CUSTODY

Sample management will consist of chain-of-custody records, sample labels and custody seals. The purpose of these procedures will be to ensure that the quality of the samples is maintained during their collection, transportation, and storage and through analysis to the final data deliverables. All sample management documentation and sample handling protocols have been developed using the USEPA Region IV-Environmental Compliance Branch *Standard Operating Procedures and Quality Assurance Manual*, (February 1, 1991).

### Sample Identification Documents:

- Sample label
- Custody seals
- Chain-of-custody records
- Field notebooks

### 6.1 Sample Labels

Sample container labels, as shown in Figure 6-1, will be required for identifying each submitted sample. The sample labels are affixed on each sample container for identification. Sample label information will include the site name, sample identification, preservation, required analysis, date of collection with time and the sampler's name. Each label must be printed in a legible manner using waterproof black ink.

Table 6-1 outlines the sample designation system to be used to identify each sample. Should additional sample designations be required, this table will be amended. Further details on the sample collection setting will be provided on the chain-of-custody record including date and time of collection.

**Figure 6-1     Sample Bottle Labels**

Table 6-1 Sample Designation System			
Location	Sample Type	QA Sample Type	Sample Location and Depth
CC = Carrier, Collierville Site	GW = Groundwater S = Soil SD = Sediment BHG = Borehole Gas Samples IN = Influent EF = Effluent OG = SVE Off Gas SG = Soil Gas	RB = Rinsate Blank FB = Field Blank TB = Trip Blank DP = Duplicate MS = Matrix Spike MSD = Matrix Spike Duplicate	B = Boring MW = Monitoring Well HA = Hand Auger Boring MP = SVE Monitoring Probe SVW = SVE Well SVE = SVE System GWT = Groundwater Treatment System  Sampling depth or location is based upon a numeric system (ex. sampling interval depth, sampling point along a treatment train)

**Examples:**

Water Matrix — CCGWMW2 = Carrier Collierville groundwater sample from monitoring well 2  
 Solid Matrix — CCSB1 = Carrier Collierville soils from boring 1  
 Air Matrix — CCOGSVE1 = Carrier Collierville off gas from SVE system at location 1

## 6.2 Custody Seals

Custody seals (also called security seals), as illustrated in Figure 6-2, will be used to ensure that samples are not tampered with during transportation. Custody seals are placed on the shipping containers and the sample containers in a manner such that the containers cannot be opened without breaking the seal.

## 6.3 Chain-of-Custody

Chain-of-custody records, as shown in Figure 6-3, will be fully completed by field personnel and shall accompany the samples during shipment. The chain-of-custody shall contain pertinent information regarding the samples, such as the samplers name, sample identification, date and time of collection, and description of the cooler's contents (number of sample containers). In addition, information to be relayed to the laboratory shall be written in the Remarks section of the chain-of-custody. For chain-of-custody purposes, all QC samples are subject to exactly the same custodial procedures and documentation as real samples.



**Figure 6-2 Custody Seals**

**Figure 6-3 Chain-of-Custody Forms**

Upon transfer of custody, the chain-of-custody form will be signed by an EnSafe representative, who will note the date and time. Because common couriers will not sign chain-of-custody forms, the chain-of-custody records will be sealed within each cooler. A signed, dated security seal will be placed over the lid opening to indicate if the cooler has been tampered with during shipment to the laboratory. All chain-of-custody forms received by the laboratory must be signed and dated by the laboratory sample custodian and returned to EnSafe following receipt, or as part of, the data reporting package.

#### **6.4 Field Logs**

All samples will be documented in accordance with the USEPA SOP/QAM, Chapter 3 - Sample Control, Field Records and Document Control. Sampling personnel will use bound, ruled or gridded logbooks with sequentially numbered waterproof pages for activity documentation pertaining to the project. These logbooks will be the master document for all site activities and accomplishments. These records will also document all visual observations, calculations and equipment calibrations. The logbooks are accountable documents that will be properly maintained and retained as part of the project files.

Each logbook will be labeled on the front cover as follows:

Carrier Site RD

Collierville, TN

EnSafe

the sampler's name

book number (books are to be sequentially numbered by distribution or as assigned by the QAO)

the starting date and the date when completed.

The logbook must be labeled with indelible black ink. The following steps shall be followed when making entries into the field logbook:

- Enter the date and time of the task's starting time, weather conditions, and the names and titles of individuals involved in the task. When possible, include the names and titles of personnel visiting the task area.

- Describe all activities in detail and include which forms, if used, were used to record such information (e.g. boring logs, field change request forms). It is considered good practice to duplicate the most important information throughout the field logbooks. Examples of some pertinent information for specific activities are:
  - **Well installation activities:** Document the elevations, reference elevations, total depth, size and length of casing and screen, casing and screen material, screen slot size, drilling conditions and rate and details on the soil lithology. Include any calculations, for example in determining well volumes.
  - **Soil boring activities:** Document the size and depth of the borehole, sampling equipment used and methods used, details on the soil lithology and the samples collected.
  - **Levels of personnel protection for the sampling team:** If the levels of protection are changed for any reason, state the change in protection and the reasons for the change.
- Detail any field tests that were conducted (e.g. PID/OVA measurements) and reference any forms that were used or other data records. Document the results, if obtainable in the field.
- Detail how the samples were collected or how the blanks/duplicates were prepared. List all label information, sample containers and volume, preservation, packaging, chain-of-custody form number and analytical parameters applicable to each sample. Also, note the time of transfer, and if possible the name of the individual to whom custody was transferred.
- List the time, equipment type and serial or identification number, and the procedures used for equipment used onsite. List the calibration records and when possible, the calibration logs used.
- List all equipment failures or breakdowns that occurred. Also, include the changes, repairs and results of the equipment failure or breakdown.

## 6.5 Corrections to Documentation

**Notebooks** — As with any data logbooks, no pages may be removed for any reason. If corrections are necessary, these must be made by drawing a single line through the original entry (so that the original entry can still be read) and writing the corrected entry alongside. The correction must be initialed and dated. Some corrected errors will require a footnote explaining the correction. Corrections to errors shall be made by the individual responsible for the entries in the field logbook.

**Sampling Forms** — As previously stated, all sample identification tags, chain-of-custody records, and other forms must be written in indelible black ink. None of these documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made on a document, the individual responsible for preparation of the document may make corrections by crossing a line through the error and entering the corrected information. The incorrect information should not be obliterated. Any subsequent errors discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

## 7.0 CALIBRATION PROCEDURES AND FREQUENCY

EnSafe personnel will calibrate all field instrumentation in accordance to the manufacturer's recommendations. Field instruments listed in Table 7-1 are expected to be used at some point in the sampling program. All equipment calibration and/or standardization procedures will be recorded in the field logbook and in the equipment logs, maintained at the home office in Memphis, Tennessee. Records shall include the source of the field standards with lot numbers and expiration dates, and a brief description of the procedures used. When necessary, the procedures will be recorded step-by-step into the records.

Table 7-1 Field Equipment Calibration		
Equipment/Measurement	Calibration Method	Frequency
pH	2 standard solutions	daily
Temperature	Compared to NBS-certified thermometer	quarterly
Combustible Gas/Photoionization Detector	standard gas	daily/each use
Conductivity/pH/Temperature Meter	2 or 3 standard solutions (function specific)	weekly, daily if necessary
Humidity/Temperature Meter	field calibrator	quarterly

## 8.0 PREVENTIVE MAINTENANCE

Sampling equipment employed by EnSafe which may require preventive maintenance will be checked for proper operation before and after use on a daily basis. Any replacements of parts or repairs will be conducted in accordance to the manufacturer's operations manual or will be sent to the manufacturer for repairs. Equipment or instruments potentially requiring preventive maintenance are listed in Table 8-1. Preventative maintenance procedures for sampling equipment which are routinely serviced are described below. Records of calibration and maintenance activities for each piece of equipment are contained in logbooks assigned to the equipment. The preventive maintenance program for all laboratory equipment will be handled solely by the laboratory's personnel in accordance with the laboratory's Quality Assurance Plan.

Table 8-1 Field Testing Equipment			
Item	Manufacturer	Model Number	Serial Number
Conductivity Meter	Myron L	pDS	0460222E
pH Meter	Fisher	Accumet 956	3218
Photoionization Detectors	Photovac	TIP II	2580147
	HNu	PI 101	—

**Note:** The actual make and model of each above instrument may be substituted by a similar model.

### Preventive Maintenance for Field Equipment

#### *Conductivity Meters*

Each use: Meter probes are cleaned before and after each use with distilled/deionized water.

Weekly: The instruments are checked with a commercial conductivity standard for proper calibration. The battery is checked for proper charge.

Quarterly: The instrument is inspected on a quarterly basis, whether used during the quarter or not. The inspection consists of a general examination of the electrical system (including batteries) and a calibration check. Instruments not functioning properly are shipped to the manufacturer for repair and calibration.

### ***pH Meters***

- Weekly: The probe shall be checked for cracks in the electrode bulb and completely filled with electrolyte solution. At the beginning and end of any sampling day, the pH meter must be calibrated using standard pH buffers of an acceptable range (4.0-7.0 or 7.0-10.0). The battery is checked for proper charge. Following each measurement, the probe is rinsed with deionized water. The probe cap is filled with electrolyte solution and placed on the probe tip. Excess electrolyte is rinsed off and the probe dried with a paper towel. The instrument is then placed in its carrying case.
- Quarterly: The instrument is inspected on a quarterly basis whether or not it has been used. The inspection consists of a general examination of the probe, wire, electrical system (battery check) and a calibration check. Any malfunctioning equipment is returned to the manufacturer for repair and recalibration.

### ***Thermometers***

- Weekly: Before each use, thermometers are visually checked for cracks and mercury separation. After use, thermometers are rinsed with deionized or distilled water and placed in their protective case to prevent breakage.
- Monthly: Thermometers are visually inspected as described above, whether used or not. They are checked against an NBS certified thermometer for accuracy.

### ***Photoionization Detectors***

- Each use: The TIP II and HNu are zeroed and calibrated using TCE span gas for the TIP II and isobutylene (benzene mimic) for the HNu, at least before and after each sampling day. Also, to be checked after each use will be the battery for a proper charge, cleanliness of the UV lamp window and the dust filters.
- Quarterly: The instrument is inspected on a quarterly basis whether or not it has been used. The instrument bulb will be cleaned monthly or more frequently as needed. The inspection consists of a general examination of the probe, wires, electrical system



(esp. battery check) and a calibration check. Any malfunctioning equipment is returned to the manufacturer for repair and recalibration.

## **9.0 DATA REDUCTION, VALIDATION, AND REPORTING**

### **9.1 Data Management**

EnSafe is currently using a database management system for the acceptance of analytical data from the laboratories into an ASCII format on a 3½-inch or 5¼-inch diskette. The database has several functions. It will store the data and allow for quick and easy retrieval of specific data, e.g. knowing a specific sample number, one may easily access the analytical data corresponding to that sample number. In addition, the database can be printed, in tabular format, for easy placement into a report. Safeguards within the system prevent accidental alterations of data. In the future, EnSafe expects the system to allow for statistical analysis of data.

### **9.2 Data Validation**

The field data package will include all field records and measurements obtained during the activity by EnSafe sampling personnel. The package will include information such as the field log books, chain-of-custody records, well/boring logs, field equipment calibration and maintenance records, and any field analytical results.

The field data package will be compiled for validation by the EnSafe's project QAO. The field data package consists of the field blanks, rinsate blanks, and trip blanks, check on field analyses for equipment calibration and condition, chain-of-custody forms for proper completion with signatures of field personnel and the laboratory sample custodian, and dates. The field data package will be reviewed by the project QAO for completeness and accuracy using the appropriate methods and the data validation guidelines provided by the SW-846 and USEPA Region IV as guidance.

The analytical data package validation will be performed by the EnSafe project QAO, but not before completion of field data validation and prior to any submittal to the USEPA. The validation procedures will be performed in accordance with the following USEPA documents:

- Contract Laboratory Program, *National Functional Guidelines for Organic and Inorganic Data Review*. Multi-Media, Multi-Concentration (OLM01.0) and Low Concentration Water (OLC01.0), Revised June 1991.

- Office of Emergency Remedial Response, *Quality Assurance/Quality Control Guidance for Removal Activities — Sampling QA/QC Plan and Data Validation Procedures*, USEPA/540/G-90/004, April 1990.

Also to be taken into consideration are the USEPA precision and accuracy statements for the analytical methods employed. The project's data validation reports and QA summaries will be reported utilizing the forms presented in Attachment E. The analytical data package validation will include as a summary, but is not limited to, the procedures outlined below.

**Data Validation Procedures:**

- Comparison of sampling dates, sample extraction dates and analysis dates to check that samples were extracted and/or analyzed within the proper holding times. Failure in this area may render the data unusable.
- Review of analytical methods and required detection limits to verify that they agree with the QAP and the laboratory contract. Non-compliance in this area without reasonable justification (i.e. severe matrix interferences) may render the data unusable.
- Review of field and laboratory blanks to evaluate possible contamination sources. The preparation techniques and frequencies, and the analytical results, if appropriate, will be considered. All internal laboratory QC sample results will also be reviewed.
- Evaluation of all blanks, i.e. rinsate blanks, field blanks, trip blanks, reagent blanks, method reagent blanks and extraction blanks. These blanks should be relatively free from contamination of the target compounds, except for common laboratory artifacts. All blank contaminants must be explained or the data applicable to those blanks labelled suspect and sufficient only for qualitative purposes.

The use of the laboratory will be accomplished by a services agreement or contract. The contract will specify the scope of services to be performed by the laboratory, the specific analytical quality assurance requirements to be met, and the information to be developed and reported.

## **10.0 INTERNAL QUALITY CONTROL CHECKS**

Internal laboratory control checks used by the laboratory will be conducted in the laboratory by its staff. The EnSafe QA officer will conduct internal quality control checks of sampling procedures and laboratory analyses. These checks will consist of preparation and submittal of sampler rinsate blanks, trip blanks, field blanks, and field duplicates for analysis and an evaluation of the laboratory analytical package. Data validation guidelines will be followed in evaluating all reported data. Analyses for which these guidelines may not directly apply (e.g. wet chemistry methods) will be reviewed by employing applicable guidelines, compliance with the analytical method and, as with any data validation, best professional judgement. The usability of data to the project will be determined by evaluating the data packages with respect to these criteria.

Analytical data quality will be assured through the use of the USEPA guidelines for QA/QC. Where screening analyses will be performed, producing data which may not be used for evidentiary purposes in subsequent investigative phases, the data may not be subject to validation.

Matrix spike samples are prepared by the laboratory and are useful in assessing the accuracy of the analytical method. Matrix spike samples can also detect matrix effects, in which other sample components interfere with the analysis of the contaminant of concern. The method of measuring analytical accuracy is percent recovery. Analysis of matrix spike duplicates will provide a basis for determining method precision specific to the matrix under investigation. Precision is measured as relative percent difference between duplicate analyses.

Analytical matrix spikes and matrix spike duplicates will be performed at a rate of one per sample batch (20 samples maximum) per matrix (see Table 5-1).

Surrogate spikes are also used to determine the accuracy of the analytical method with respect to the matrix under investigation. Surrogate spike compounds are compounds similar in chemical nature to the target compounds, but are not expected to be in the affected media. These compounds are introduced into each sample before analysis.

By comparing the reported results for these compounds with the quantities introduced, a percent recovery can be determined. The percent recovery data are subsequently used to assess the accuracy of results for target compounds within each specific sample. Surrogate spike analyses will be performed on each sample analyzed for organic parameters.

The choice of compounds to be used for matrix and surrogate spike purposes is generally stipulated by the analytical method employed. Tables 10-1 and 10-2 list compounds to be targeted for this purpose in performing CLP level analyses, along with QA limits for each.

Table 10-1: CLP TCL-VOC Quality Objectives Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes					
Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (%Recovery)	Water Precision (%RPD) <sup>A</sup>	Water Accuracy (%)
VOA	Matrix Spikes				
	1,1-Dichloroethylene	22	59-172	14	61-145
	Trichloroethylene	24	62-137	14	71-120
	Chlorobenzene	21	60-133	13	75-130
	Toluene	21	59-139	13	76-125
	Benzene	21	66-142	11	76-127
VOA	Surrogate Spikes				
	Toluene-d <sub>8</sub>	---	84-138	---	88-110
	4-Bromofluorobenzene	---	59-113	---	86-115 <sup>B</sup>
	1,2-Dichloroethane-d <sub>4</sub>	---	70-121	---	76-114

**Note:**

QA/QC Requirements excerpted from 3/90 CLP SOW.

A — Relative percent difference. Note these values are highly matrix dependent.

B — The bromofluorobenzene QC limits in the 10/92 SOW is 80% - 120% in recovery. The new 10/92 SOW only requires one surrogate and matrix spikes are not require at all.

Table 10-2: CLP Metals Analyses Data QA Objectives Matrix Spikes/Duplicate Analyses			
Analyte (Metal)	Medium/High Sample Precision <sup>A</sup> (%RPD)	Low Sample Precision <sup>B</sup> (%RPD)	Accuracy (% Spike Recovery)
Lead	± 20	± CRDL	75-125
Zinc	± 20	± CRDL	75-125

**Notes:**

QA/QC Requirements excerpted from CLP SOW ILM01.0

- A - Medium/High Samples = metal present at 5 times (or more) the contract required detection limit (CRDL).
- B - Low Samples = metal present at less than 5 times the CRDL.

## **11.0 PERFORMANCE AND SYSTEM AUDITS**

Audits will be performed before and during the work to evaluate the capability and performance of the entire system of measurement and reporting. The system includes experimental design, sampling, data collection, analysis, and attendant quality control activities.

### **11.1 Field System Audits**

The QAO and the project manager may make routine visits to the project site to evaluate the performance of field personnel, general field operations and progress. Observations will also include the performance of the field operations personnel during each type of activity, i.e., water level measurements and sampling rounds. A formal systems audit of field operations by the project QAO will be performed on a biannual basis and a field audit report of the sampling team will be maintained on file at EnSafe.

### **11.2 Laboratory Systems Audit**

A laboratory systems audit of the contracted laboratories is routinely conducted (at least biannually) by EnSafe. These audits test methodology and ensure that systems and operational capability is maintained. They also verify that quality control measures are being followed as specified in the laboratory SOPs and the EnSafe project QAPP. The systems audit checklist used by the USEPA forms the procedural basis for conducting these audits. The results of audits are maintained on file at the EnSafe office.

### **11.3 Performance Evaluation Audits**

A performance evaluation (PE) audit evaluates a laboratory's ability to obtain accurate and precise results in the analysis of known check samples by a specific analytical method. The laboratory was chosen on the basis of ability to meet the QA/AC requirements of this project. The laboratory selection was also based on previous work performance for EnSafe. During or following the analytical data validation described in Sections 9 and 10 of this QAPP, a performance evaluation audit of the laboratory may be initiated by the project QA officer. This audit may be conducted if it is determined that the QA data provided are outside acceptable control limits. These PE audits may include a review of all raw data developed by the laboratory and not reported (laboratory non-reportables) and the submission of blind spiked check samples for the analysis of the parameters in question. These check samples may be submitted disguised as field samples. In this case, the laboratory will not know the purpose of

the samples; or the samples may be obvious (known) check samples or National Bureau of Standards traceable.

PE audits also may be conducted by reviewing the laboratory's results from round-robin certification testing and/or USEPA initiated evaluation samples. An additional component of PE audits includes the review and evaluation of raw data generated from the analysis of PE samples and actual field samples that may be in question.

#### **11.4 Regulatory Audits**

It is understood that EnSafe field personnel and subcontract laboratories also are subject to quality assurance audits by the USEPA and the TDEC.



## 12.0 PROCEDURES TO ASSESS DATA ACCURACY, PRECISION, AND COMPLETENESS

Performance of the following calculations will be documented and included in the applicable QC reports.

### 12.1 Accuracy

Accuracy is the difference between an average value and the *true* value when the latter is known or assumed. The term *accuracy* is normally used interchangeably with *percent recovery*, and describes either recovery of a known amount of analyte (spike) added to a sample of known value, or recovery of a synthetic standard of known value.

$$\text{Percent Recovery} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100\%$$

Where:

SSR        =     Spike sample results;  
SR         =     Sample result; and  
SA         =     Spike added.

Note: The units for the concentrations of spikes, samples, and observed and true values vary based on the analysis. However, they are typically  $\mu\text{g/L}$  or  $\text{mg/L}$  for water samples and  $\mu\text{g/kg}$  or  $\text{mg/kg}$  for soil samples.

### 12.2 Precision

Relative to the data from a single test procedure, precision is the degree of mutual agreement among individual measurements made under prescribed conditions. An estimate of standard deviation is normally used to describe the precision of a method.

#### Standard Deviation Estimate

The standard deviation estimate is the most widely used measure to describe the dispersion of a set of data. Normally,  $+ \text{SD}$  will include 68 percent, and  $+ 2\text{SD}$  will include about 95 percent of the data from a study.

### Relative Standard Deviation (RSD)

The estimate of precision of a series of replicate measurements will be expressed as the RSD.

### Relative Percent Difference (RPD)

A measure of the difference between two samples assumed to be identical through dividing (splitting) an original sample, analyzing each portion, identifying the values of the first replicate (X1) and that of the second replicate (X2), and dividing the difference by the mean (X) of X1 and X2 is expressed as the RPD.

## 12.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the total amount expected to be obtained under normal conditions. A 95 percent completeness figure is usually required for a particular analysis and overall project objective.

## 12.4 Quality Control Charts

QC charts are prepared after every 20 determinations of precision and accuracy. The charts are prepared by determining the means of the determinations, setting warning limits of +2 standard deviations, and setting control limits of +3 standard deviations from the mean. The following equations are used:

$$\text{Mean} = \frac{\sum_{i=1}^n X_i}{n}$$

$$\text{Standard Deviation} = \frac{\sum_{i=1}^n X_i}{n-1}$$

Where:

- n = the number of determinations  
x<sub>i</sub> = the numerical value for the i<sup>th</sup> determination.

Analysis is considered *out of control* whenever one of the following occurs:

- One or more values are outside control limits.
- Two consecutive values fall outside warning limits.
- Seven consecutive values fall on the same side of the mean.

In the event of an *out-of-control* analysis, corrective action will be initiated as described in Section 13.

### **13.0 CORRECTIVE ACTION**

During the course of any investigation, field personnel are responsible for seeing that field instruments and equipment are functioning properly and that work progresses satisfactorily. The field personnel are also responsible for ensuring performance of routine preventive maintenance and quality control procedures. If a problem is detected by the field personnel, the project manager shall be notified immediately. Similarly, if a problem is identified during a routine audit by the project QAO or the regulatory QA officer, an immediate investigation will be undertaken and corrective action deemed necessary will be taken as early as possible.

Potentially out-of-control situations include field instrument breakdown, mislabelling or loss of samples, inadvertent contamination of samples, or circumstances which preclude performance of field activities in accordance with the QAPP or other work plan documents. If an out-of-control event occurs, field sampling personnel shall make appropriate contacts and document any remedial efforts taken to bring field activities under control. The immediate contacts shall be the EnSafe project manager and/or the EnSafe QAO. The EnSafe project manager shall decide whether further contacts are to be made to Carrier, USEPA or the TDEC. Formal documentation of out-of-control occurrences and any associated corrective actions recommended or initiated shall be written on the EnSafe — Field Change Request Forms. Field personnel shall also make notes and comments of the out-of-control occurrence in the field logbooks.

All variances or changes from project QAP are subject to approval by the USEPA remedial project manager and the TDEC representative. If circumstances arise which require significant changes in the protocols, methods, or techniques outlined in the work plan and/or the QAPP, the USEPA RPM and/or the TDEC project manager may be contacted. Any USEPA or TDEC alterations will be documented and implemented with the agency's written consent.

## **14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT**

### **Internal QA Reports**

The QA officer will provide internal QA reports to the Project Manager. The reports address the following, as applicable during the course of the project.

- quality assurance activities and quality of collected data
- equipment calibration and preventive maintenance activities
- results of data precision and accuracy calculations
- evaluation of data completeness
- QA problems with recommendations and/or implemented corrective actions
- QA performance and system audit findings

### **Reports to Oversight Agencies**

Carrier will provide QA reports to the appropriate agency QA officer(s) along with sampling reports to be submitted at completion of each project phase. QA (or Data Validation) reports will include, but are not limited to, a discussions of the following.

### **QA or Data Validation Report**

- numbers, locations and types of samples collected
- analyses performed
- field and laboratory QA sample results and implications
- data qualification, validity and overall quality
- analytical problem areas with corrective actions taken, if any
- impact of data quality on subsequent data usage

A quality assurance section of the final report will be submitted at the conclusion of the project.

### **Status Reports**

Periodic status reports shall be submitted to the USEPA with respect to the project activities undertaken in accordance with the RD SOW. The status reports shall be submitted on or before the fifteenth day of each month beginning on the effective date of the UAO and continuing until the USEPA, in the form of a written notice, determines the terms of the UAO to be completed.

The status report shall describe: (1) all significant onsite and offsite activities, whether they are administrative or operational, including the progress of those activities, (2) the results of all sampling and testing with other data obtained during the course of the activities relevant to the RD, (3) activities planned for the following period with schedules of the anticipated dates, (4) all site problems and delays, corrective measures, public relations activities, or any significant event that occurs during the site activities. Status reports will not be submitted when there are no field activities or data collected.

Status reports will also be submitted in conjunction with the site's monitoring program with all information as described above in the monthly status reports. A copy of the status report will remain on file at EnSafe's Memphis office.

## **15.0 PERSONNEL QUALIFICATIONS AND RESUMES**

Resumes of primary EnSafe project personnel are included as Attachment F.

The qualifications, or a copy of the subcontractor's Statement-of-Qualifications will be submitted upon selection of the subcontractor.

**APPENDIX E**  
**HEALTH AND SAFETY PLAN**



## Table of Contents

1.0	INTRODUCTION	E-1
2.0	APPLICABILITY	E-2
3.0	SITE CHARACTERIZATION	E-3
3.1	Work Areas	E-3
3.2	Work Area Access/Egress	E-6
3.3	Limiting Access to the Site Work Area	E-7
3.4	Site Communications	E-8
4.0	SITE ACTIVITIES	E-9
5.0	HAZARD EVALUATION	E-10
5.1	Chemical Hazards	E-10
5.2	Mechanical, Physical and Temperature Hazards	E-12
5.3	Site Hazard Abatement Methodology	E-12
5.4	Noise Hazards	E-14
6.0	EMPLOYEE PROTECTION	E-16
6.1	Standard Safe Work Practices	E-16
6.2	Personal Protective Equipment	E-16
6.3	Maintenance	E-24
6.4	Safety Equipment	E-24
6.5	Procedures and Equipment for Extreme Weather Conditions	E-24
6.6	Work Limitations	E-29
6.7	Exposure Evaluation	E-30
7.0	MONITORING REQUIREMENTS	E-31
7.1	Air Monitoring	E-31
7.2	Confined Space Entry Procedures	E-32
8.0	DECONTAMINATION	E-34
8.1	Personnel Decontamination	E-34
8.2	Equipment Decontamination	E-34
8.3	Closure of the Personnel Decontamination Station	E-35
9.0	AUTHORIZED PERSONNEL/RESPONSIBILITIES	E-36
9.1	Responsibilities of the EnSafe Site Manager	E-36
9.2	Responsibilities of the Site Health and Safety Officer	E-37
9.3	Responsibilities of Onsite Field Personnel	E-38

10.0	EMERGENCY INFORMATION	E-40
10.1	Site Resources	E-40
10.2	Pre-Emergency Planning	E-41
10.3	Personnel Roles and Lines of Authority	E-41
10.4	Evacuation Routes/Procedures	E-42
10.5	Location of the Nearest Hospital Capable of Treating Chemical Exposures	E-45
10.6	Emergency Contact/Notification System	E-45
10.7	Emergency Medical Treatment Procedures	E-45
10.8	Fire or Explosion	E-46
10.9	Spills or Leaks	E-46
10.10	Emergency Equipment/Facilities	E-46
11.0	CONTINGENCY PLAN	E-47
11.1	Incident Command System	E-47
11.2	Notifications and Emergency Communications	E-49
11.3	Site Resources	E-49
11.4	Personnel Roles and Lines of Authority	E-51
11.5	Fire or Explosion	E-51
11.6	Spills or Leaks	E-52
11.7	Emergency Equipment/Facilities	E-52

### List of Figures

Figure 3.1	Location Map	E-4
Figure 3.2	Site Map	E-5
Figure 6.1	Individual Heat Stress Monitoring Log	E-28
Figure 10.1	Emergency Facilities Plan	E-43
Figure 10.2	Map of Route to Germantown Community Hospital	E-44
Figure 11.1	Site Resources	E-50

### List of Tables

Table 3-1	Signals and Their Meaning	E-8
Table 5-1	Exposure Guidelines for Site Chemical Hazards	E-11
Table 5-2	Hazards	E-13
Table 6-1	Level of Protection and Criteria	E-19
Table 6-2	PPE Maintenance Checklist	E-22
Table 7-1	Exposure Guidelines for Site Chemical Hazards	E-33
Table 9-1	Items to be Discussed at Safety Briefings	E-37
Table 10-1	Emergency Contact List	E-40

### **List of Attachments**

Attachment 1 Material Safety Data Sheets (Site Chemical Hazards)

Attachment 2 Accident Report Form

Attachment 3 Drilling Safety Guidelines

## 1.0 INTRODUCTION

The following is the Health and Safety Plan (HSP) for the Carrier Collierville Remedial Design Work Plan. This HSP is submitted in accordance with the Amended Administrative Order and Scope of Work (SOW). The SOW and Order define the activities required to complete the remedial design and remedial activities and the operation and maintenance activities at the Carrier Collierville site (the site). This plan specifies the procedures and protective measures that will be employed to ensure the health and safety of the individuals working in and around the site, and those who reside and/or work in the vicinity of the site. The activities during remedial design are as follows:

- Installation of soil vapor extraction wells and monitoring probes in the TCE spill area.
- Collection of soil vapor samples from TCE spill area soils.
- Performance of a soil vapor extraction pilot study in the TCE spill area.
- Installation and associated development and sampling of a down gradient groundwater monitoring well.

As the remedial design and remedial action activities are further defined, the site HSP will be modified to specifically address those activities. The requirements of 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response Actions have been incorporated.

## 2.0 APPLICABILITY

The provisions of this plan are mandatory for all Environmental and Safety Designs, Inc. (EnSafe) employees and EnSafe subcontractors engaged in onsite operations who will be exposed to or have the potential to be exposed to onsite hazardous substances.

Carrier contractors will use the Remedial Design Work Plan HSP as prepared by EnSafe or shall submit their own for EPA and EnSafe approval. EPA personnel and EPA oversight contractor personnel will work within the provisions of their own health and safety plans. All personnel performing remedial design field activities must become familiar with this HSP and sign the plan acceptance form. Subcontractors will hold EnSafe harmless from, and indemnify it against all liability in the case of any injury. At a minimum, all provisions of the EnSafe HSP will be followed.

EnSafe will suspend site activities and evacuate the area under the conditions listed below:

- If inadequate safety precautions are being performed by contractors, EPA, or EPA oversight contractors.
- If it is believed that any site personnel are in a position in which they may be exposed to an immediate health hazard.

All Carrier contractors, EnSafe subcontractors, EPA personnel, EPA oversight contractors and EnSafe personnel will be responsible for operating in accordance with the most current Occupational Safety and Health Administration (OSHA) regulations including 29 CFR 1910.120 - Hazardous Waste Operations and Emergency Response and 29 CFR 1926 Construction Industry Standards as well as other applicable OSHA Regulations.

### **3.0 SITE CHARACTERIZATION**

#### **3.1 Work Areas**

The Collierville site is located on the western side of Shelby County, Tennessee as is indicated on Figure 3.1. A site map is shown on Figure 3.2. Site control will be established and maintained according to the recommendations set forth in the EPA's "Interim Standard Operating Safety Guides, Revised September, 1982." Three general zones of operation will be established to reduce the potential for contaminant migration and risk of personnel exposure.

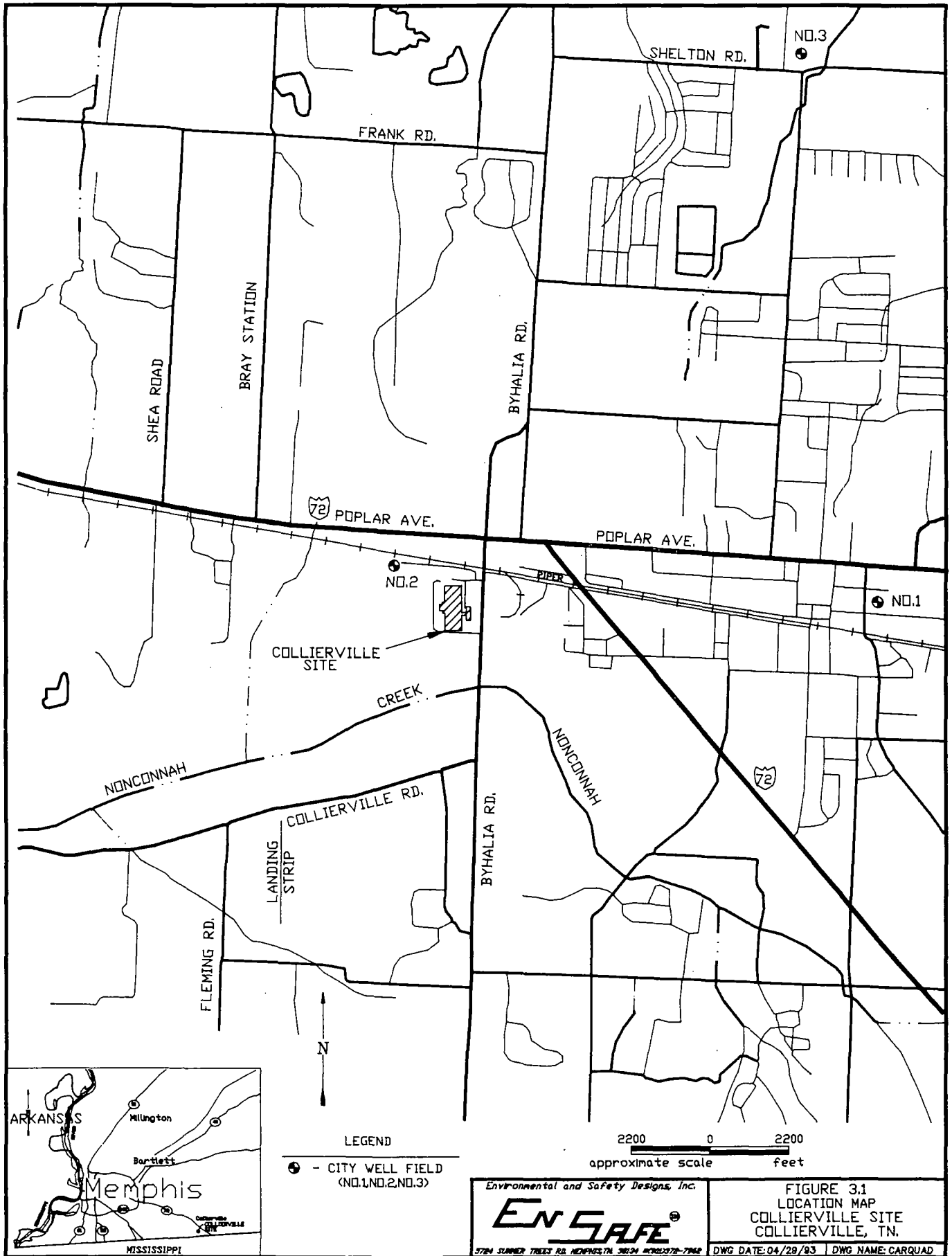
- the exclusion zone
- the contamination reduction zone
- the support zone

**An exclusion zone** will encompass the area inside of the trichlorethylene (TCE) spill area in which the soil vapor extraction study is to take place. The exclusion zone will be established using existing site physical assets and barricade tape.

The exclusion zone for the groundwater extraction well installation activities will encompass a radius of 20 feet around the drill rig. The exclusion zone will be established using existing site physical assets and barricade tape. In the event that the extraction well is located with 25 feet of a Route 72, a major thoroughfare, the exclusion zone will be extended to include all of the area required for the work up to the gravel shoulder of the road. The exclusion zone boundary at this location will be established using wooden or metal barricade markers with appropriate traffic warning signs. Shelby County Sheriff's Department will be notified of the work and will be involved in the type and placement of warning signs and barricades.

Each exclusion zone is considered contaminated and all personnel within the area must use the prescribed level of personal protection. A checkpoint will be established at the periphery of each exclusion zone to regulate the flow of personnel and equipment in and out of the area. The exclusion zone boundary is the "hotline." All personnel crossing the hotline into the exclusion zone must use the "buddy system."

Only authorized personnel with a minimum of 40 hours health and safety training meeting the requirements of OSHA 29 CFR 1910.120 and a site-specific health and safety briefing are permitted within the exclusion and contamination reduction zones.



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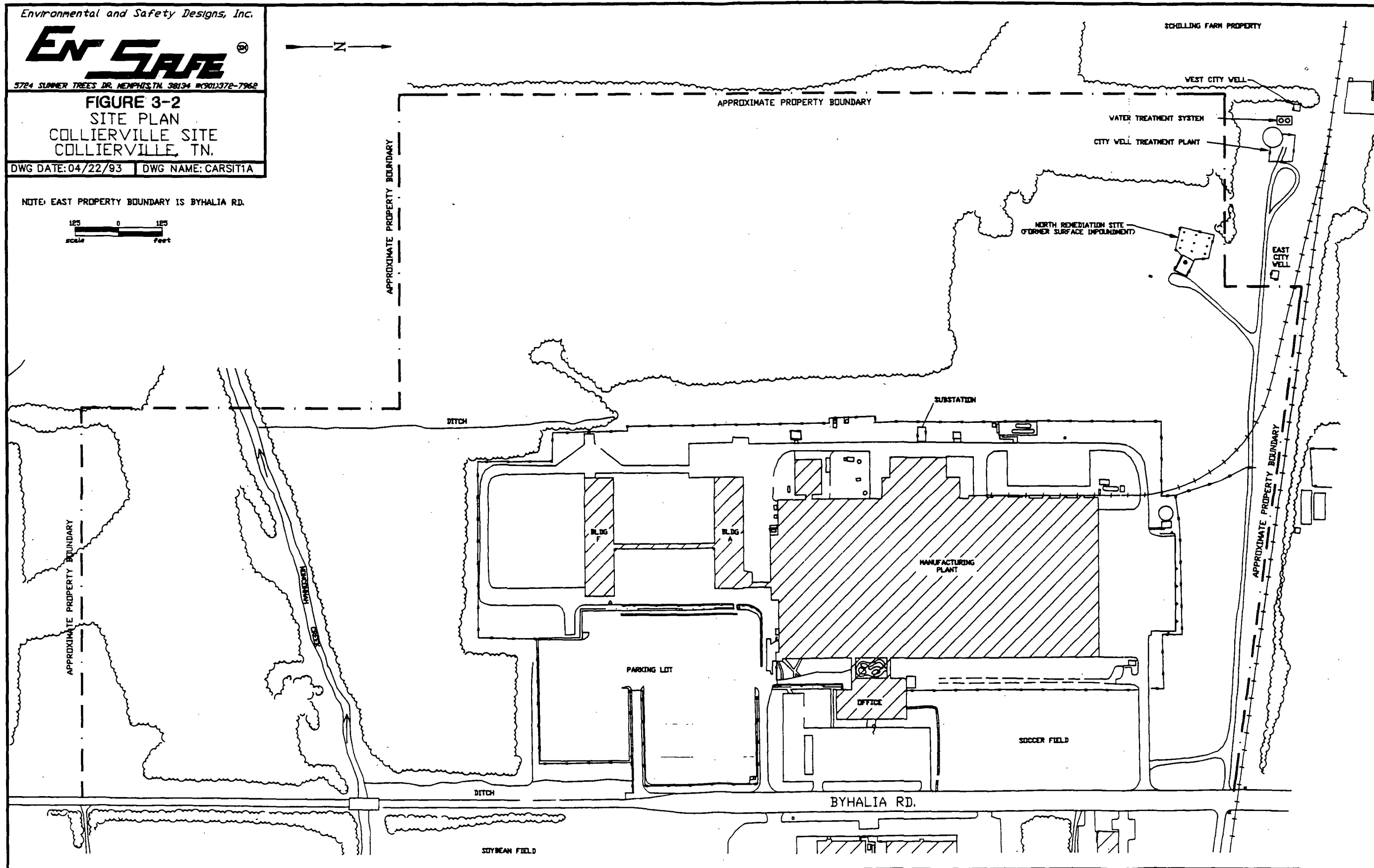
5724 SUMMER TREES DR. MEMPHIS, TN 38134 MK301372-7962

**FIGURE 3-2**  
**SITE PLAN**  
**COLLIERVILLE SITE**  
**COLLIERVILLE, TN.**

DWG DATE: 04/22/93 DWG NAME: CARST1A

NOTE: EAST PROPERTY BOUNDARY IS BYHALIA RD.

125 0 125  
Scale Feet





Each person entering the exclusion zone shall be accompanied by a person who is capable of the following:

- Buddy system
- Provide his/her partner with assistance.
- Observe his/her partner for signs of chemical or heat/cold exposure.
- Periodically check the integrity of his/her partner's protective clothing.
- Notify the shift supervisor or his representative or others if emergency help is needed.

For any activity in which level B or C PPE is prescribed, at least one person shall remain outside the exclusion zone and have available at least the same level of PPE as the "buddies" who are entering the exclusion zone. The person outside the exclusion zone will act as the safety observer and perform the security duties described in Section 3.2 of this plan. All other activities shall be completed using the "buddy system". Additionally the team will have immediately available a means of communication to summon response teams in the event of an emergency.

**The contamination reduction zone** will serve as an area between the exclusion zone and the support zone and is intended to prevent the spread of contaminants from the work areas. The personnel decontamination zone will primarily consist of an area for decontamination of boots and doffing of protective coveralls, gloves, and respiratory protection equipment. All equipment and machinery decontamination will take place at the existing decontamination pad. Entry into the contamination reduction zone from the support zone will be through a controlled access point. Personnel entering into this area must wear the prescribed personal protective equipment. Exit from the contamination reduction zone requires the removal of all contaminants through compliance with established decontamination procedures.

**The support zone** is the outermost area and is considered a non-contaminated or clean area. The command post for field operations, first aid station and other site support elements are located in the existing site command trailer.

### **3.2 Work Area Access/Egress**

The remedial design activities will be completed in a single shift during daylight hours. Activities will be completed by a known number of site workers under close observation of EnSafe personnel.

All personnel entering the site exclusion zone must perform the following activities:

1. Check in with the on-going operations shift supervisor (or representative at the command trailer). All entry to the site work areas must be through the personnel decontamination zone.
2. Provide the shift supervisor with the following information:
  - The names of individuals entering the site work area.
  - Destination in the site work area.
  - Activity to be performed at that location.
  - Duration of the planned activity.
  - When supplied air respirators are being used, the amount of air available to each individual.
3. The shift supervisor will inform persons entering the site work area of the location of other activities taking place during the scheduled entry. If the shift supervisor determines it is not safe for the scheduled entry, he can reschedule the entry or stop all other activities to perform the specific task.
4. Conduct a communications check to ensure that all equipment is operating correctly before entering the site work area. A communications check will be conducted at least once an hour to ensure that equipment is working properly.
5. Upon exiting the site personnel decontamination station proceed directly to the command trailer and check out with the on-going operations shift supervisor or his representative. All exits from the site work area must be made through the personnel decontamination station.
6. Perform all necessary decontamination prior to departing the personnel or equipment decontamination station.

### **3.3 Limiting Access to the Site Work Area**

Access to the site work area will be limited to the South Gate and upon clearance by Carrier Security. The remaining area is fenced and posted to prohibit entry and is patrolled by Carrier Security. Carrier Security will maintain all fences and will control access to the site.

### 3.4 Site Communications

#### 3.4.1 Communications Between Team Members

Operations at this site will be limited to relatively small work areas. Communications between team members (including the person responsible for team safety) will be through the use of FM radios. Radios will be checked daily prior to the start of field operations to assure that they are working. Radios will be maintained in accordance with the manufacturer's recommendations. Radio and hand signals will be used to:

- Alert team member of emergency situations
- Transmit safety information
- Communicate changes in work schedule
- Maintain site control

Hand signals and their meanings are shown in Table 3-1.

Table 3-1 Signals and Their Meanings	
Signal	Definition
Hands clutching throat	Out of air/cannot breathe
Hands on top of head	Need assistance
Thumbs up	OK/I understand
Thumbs down	No/negative
Arms waving upright	Send back support
Grip partners wrist	Exit area immediately

#### 3.4.2 External Communications

All site personnel will communicate through telephones located in the command post. Additionally portable car telephones are normally available onsite. These forms of communication will be used to:

- Coordinate emergency responses
- File reports
- Maintain contact with offsite personnel

#### **4.0 SITE ACTIVITIES**

The scope of work defines the activities to be performed in order to complete the response activities which include the remedial design, the remedial action, and the operation and maintenance activities at the Carrier Collierville site. The activities to be covered under this plan will be limited to the following:

- Installation of soil vapor extraction wells and monitoring probes in the TCE spill area.
- Collection of soil vapor samples from TCE spill area soils.
- Performance of a soil vapor extraction pilot study in the TCE spill area.
- Installation and associated development and sampling of a down gradient groundwater monitoring well.

As the remedial design and remedial action activities are further defined, the site HSP will be modified to specifically address those activities.

## **5.0 HAZARD EVALUATION**

### **5.1 Chemical Hazards**

Analytical results from the remedial investigation/feasibility study revealed groundwater samples contaminated with trichloroethylene, 1,2-dichloroethylene, 1,1-dichloroethylene, tetrachloroethylene, and vinyl chloride. Constituents of concern include trichloroethylene, 1,2-dichloroethylene isomers, 1,1-dichloroethylene, tetrachloroethylene, vinyl chloride, lead, and zinc. It is anticipated that soils and groundwater that are to be handled by personnel in the TCE spill area contain TCE, 1,2-dichloroethylene and vinyl chloride. Table 5-1, Exposure Guidelines For Site Chemical Hazards, summarizes the exposure levels and critical physical information about the suspected site chemical hazards. Attachment 1 contains Material Safety Data Sheets (MSDS) for the respective site chemical hazards.

**Trichloroethylene** is extremely volatile and has been identified as a suspected carcinogen. Acute exposure by inhalation (TLV-TWA 50 ppm, STEL 200 ppm) can cause mucous membrane irritation and CNS depression (vertigo, visual disturbance, headache). Acute exposure by constant with skin or mucous membranes can cause nausea, vomiting, eye irritation, dermatitis, and cardiac arrhythmias. Chronic low level exposure can result in liver and kidney dysfunction.

**Tetrachloroethylene** (TLV-TWA 50 ppm, STEL 200 ppm), **1,1-dichloroethylene** (TLV-TWA 5ppm, STEL 20ppm), and **vinyl chloride**(TLV-TWA 5ppm) are identified as carcinogenic. Each of these chemicals is a halogenated hydrocarbon which exhibits high vapor pressures and low solubility in water. As a class, halogenated hydrocarbons cause varying amounts of mucous membrane irritation and CNS depression; they are also nephrotoxic and hepatotoxic.

**1,1-Dichloroethylene** (PEL 1ppm, TLV-TWA 5ppm, STEL 20ppm) is a volatile, colorless liquid which is classified as carcinogenic by the EPA and NIOSH. Chronic inhalation exposure can induce angiosarcoma in the liver and adenosarcoma of the kidney and/or liver and kidney dysfunction. Acute inhalation exposure results in CNS depression. Skin contact causes irritation.

**Vinyl Chloride** (PEL 1ppm, TLV-TWA 5ppm, Ceiling 5ppm[15 min]) is a colorless, highly flammable gas with an ethereal odor and is classified as a human carcinogen by the EPA, NIOSH, and OSHA. Vinyl chloride causes narcosis, incoordination, weakness, hepatomegaly, pallor or cyanosis of the extremities, and bleeding of the gastrointestinal tract, as well as hepatic angiosarcomas and other cancers.

<p style="text-align: center;"><b>Table 5-1</b> <b>Exposure Guidelines for Site Chemical Hazards</b></p>					
<b>Chemical Name</b>	<b>Odor Threshold (ppm) <sup>4</sup></b>	<b>OSHA PEL (ppm) <sup>1</sup></b>	<b>ACGIH TLV (ppm) <sup>2</sup></b>	<b>NIOSH REL (ppm) <sup>3</sup></b>	<b>Site Action Levels <sup>5,6</sup></b>
Trichloroethylene (TCE)	50 ppm	50 ppm 200 Ceiling	50 TWA 200 STEL	25 ppm	25 ppm (5 ppm)
1,1-Dichloroethylene	500 ppm	1 ppm	5 TWA 20 STEL	—	0.5 ppm (5 ppm)
Vinyl chloride	3000 ppm	1 ppm 5 ppm Ceiling	1 ppm 5 ppm Ceiling	Lowest Feasible Concentration	0.5 ppm (5 ppm)
1,2-Dichloroethylene	6.0-10.0 ppm	200 ppm	200 ppm	200 ppm	100 PPM (5 ppm)
Tetrachloroethylene	—	25 ppm 200 Ceiling	50 TWA 200 STEL	Lowest Feasible Concentration	12.5 PPM (5 ppm)
Total Dust	—	15 mg/m <sup>3</sup>	10 mg/m <sup>3</sup>	—	5 mg/m <sup>3</sup>
Lead	—	0.05 mg/m <sup>3</sup> 0.03 (Action Level)	0.15 mg/m <sup>3</sup>	0.10 mg/m <sup>3</sup>	0.03 mg/m <sup>3</sup>

**Notes:**

- 1 29 CFR 1910.1000, Table Z-1-A. Limits For Air Contaminants, as amended through 1/15/91.
- 2 1990 - 1991 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH
- 3 NIOSH Pocket Guide to Chemical Hazards, September 1985
- 4 Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989, Range of All Reference Values
- 5 Site Action Levels calculated as 50% pf TVL or PEL (as measured by NIOSH methods)-which ever is lower
- 6 Site Action levels for VOC's as measured by Real Time Photoionization detector = 5 ppm

**1,2-Dichloroethylene** (PEL 200 ppm, TLV-TWA 200 ppm) is a colorless liquid with a sweet, pleasant odor and is insoluble in water and soluble in alcohols. 1,2-DCE can act as a primary irritant, producing dermatitis and irritation of mucous membranes. Its principle systemic action is as a narcotic with CNS depression or, in milder exposures, nausea, vomiting, weakness, tremor, and epigastric cramps.

**Lead** (PEL 0.05 mg/m<sup>3</sup>, TLV-TWA 0.15 mg/m<sup>3</sup>) is a metallic element that is heavy, ductile and is rarely soluble in water. Exposure to airborne dusts or fumes of inorganic lead causes central nervous system effects, peripheral neuropathy, gastrointestinal disturbances, and anemia.

**Zinc** (PEL 10 mg/m<sup>3</sup>, TLV-TWA 10 mg/m<sup>3</sup>) is a bluish-white metal which exhibits low toxicity when ingested by mouth. Only severe exposure to zinc fume results in toxic effects which largely resemble metal fume fever.

Dust generated from activities within the respective exclusion zones may be associated with TCE and any of the halogenated hydrocarbons, or a combination of these chemicals. Physical effects resulting from the inhalation or ingestion of this dust may result in any of the above mentioned effects or any combination of the effects.

## **5.2 Mechanical, Physical and Temperature Hazards**

The mechanical, physical and temperature hazards associated with field activities are summarized in Table 5-2.

## **5.3 Site Hazard Abatement Methodology**

### **5.3.1 Heavy Equipment Operations**

Self-propelled equipment must be inspected by the equipment maintenance contractor and the equipment operator before being placed in operation. Defects that affect safety will be corrected in a timely manner to prevent a hazard to humans.

When defects do make continued operation hazardous to humans, the defective equipment will be taken out of service and placed in the designated area for repair. Once removed from service, the equipment cannot be used again until the defects are repaired.

Defects that affect safety will be reported to the site manager, if they are not corrected immediately. The site manager will keep a log in the decontamination station that will include the date the defect was reported, the identification of the piece of equipment, a description of the defect, and the date of repair.

Table 5-2 Hazards					
Field Activity	Mechanical Equipment Used	Electrical Hazard	Chemical Hazard	Physical Hazard	Temperature Hazard
Surface soil sampling	None	None	Inhalation of dust particles, vapors, or gases, accidental ingestion, skin absorption eye contact	Slip, trip, fall	H/C Stress
Subsurface soil sampling	Auger	None	Inhalation of dust particles, vapors, or gases, accidental ingestion, skin absorption, eye contact	Slip, trip, fall	H/C Stress
Groundwater monitoring well, installation, sampling	Drill Rig	None	Inhalation of dust particles, vapors, or gases, accidental ingestion, skin absorption, eye contact	Struck by, caught between, pinch points on machinery, slip, trip, fall, noise	H/C Stress
Installation of Soil Vapor Extraction System	Drill Rig	None	Inhalation of vapors, or gases, accidental ingestion, skin absorption, eye contact	Struck by, caught between, pinch points on machinery, slip, trip, fall, noise	H/C Stress

Operators of self-propelled mobile equipment will maintain control of the equipment while it is in motion. All operator shall obey the traffic regulations and limits imposed by Carrier Security. Improper or careless operation of mobile equipment is grounds for removal from the site.

Repair or maintenance of equipment will be performed only after the power is off, and the equipment blocked against hazardous motion. Starting or moving the equipment is allowed for adjusting or testing, provided that precautions are taken to protect the people involved. Mobile equipment will not be left unattended unless the controls are placed in the park position and the parking brake, if provided is set, and the ignition turned off. Persons will not work on top of, under, or from mobile equipment in a raised position until the equipment has been blocked or secured to prevent it from rolling or falling accidentally.

For safety procedures related to the operation of mobile drill rigs please refer to Attachment 3, Drilling Safety Guidelines. All mobile drill rigs will be moved only when the drill rig in the down position. Care will be taken to locate all overhead power lines prior to raising the drill rig. Under no circumstances, should the drill rig boom (or any other part thereof) be positioned within 10 feet of exposed and energized electrical wires. The drill rig operator will be sure that there is sufficient overhead clearance before raising the drill rig through careful preplanning, (i.e., the drill rig will not hit or touch any overhead obstruction when raised nor will it hit or touch any object while being raised.)



### **5.3.2 Chemical Hazards**

Sources of ignition such as matches and lighters will not be taken onto the site. The supervisor will ensure that personnel entering the site leave all ignition sources at the decontamination station. Section 6 describes methods of protection from chemical hazards.

### **5.3.3 Physical Hazards During Non-Self-Propelled Mobile Equipment Operations**

When conducting operations or survey work on foot, personnel will walk at all times. Running greatly increases the probability of slipping, tripping, and falling.

### **5.3.4 Temperature Hazards**

See Section 6.5 of this plan for methods for addressing heat stress and cold exposure.

### **5.3.5 Site Preparation**

All electric, gas, water, steam, sewer and other service lines that may potentially be damaged by the site work will be located before proceeding with any intrusive work. Any utility company which may be involved will be notified to identify and mark the utility lines.

## **5.4 Noise Hazards**

In addition to the hazards presented in Table 5-2, tests should be conducted for occupational exposure to noise for each field activity to determine if hearing protection is needed. Positive hearing conservation measures will be taken:

- (1) When employees are exposed to noise equal to or exceeding an 8-hour time weighted average sound level (TWA) of 80 decibels. (Decibels are measured on the A scale, slow response.)
- (2) When noise exposures equal a dose of 50 percent.

Because of the types of operations at this site, it is not anticipated that administrative or engineering controls will be feasible. Therefore, earmuff hearing protection will be issued to those working in areas where the sound level equals or exceeds an 8-hour TWA of 85 decibels. The hearing protection will comply with ANSI S12.6-1984. The instrument used to measure sound levels will be field calibrated before and after each use.

Sound monitoring will be repeated when changes are made that will affect the noise level, including changes in equipment or operating locations. Monitoring will be repeated at least monthly whenever operations are being conducted at a site where the initial 8-hour TWA was

determined to be less than 80 decibels. Hearing protection will be required for continued activity at any site where the sound level exceeds an 8-hour TWA of 80 decibels. Hearing protection will be provided to the individual employees.

Each shift supervisor is responsible for ensuring that hearing protectors are worn by: (1) employees who work in areas where the noise level has been determined to equal or exceed 80 decibels, (2) employees who have not had a baseline audiogram, or (3) employees who have experienced a standard threshold shift. Initial and annual training will be provided in the proper use and care of the hearing protectors provided to employees.

A log will be maintained onsite which shows the date of testing, the location, the type of field activity being monitored, personnel working at that location, a record of the calibration of the meter used in monitoring, and the 8-hour TWA at that site.

## **6.0 EMPLOYEE PROTECTION**

Employee protection for this project includes standard safe work practices, personal protective equipment, procedures and equipment for extreme weather conditions, work limitations and exposure evaluation.

### **6.1 Standard Safe Work Practices**

A primary goal of EnSafe is the prevention of all occupationally related injuries and illnesses. The following practices are presented as general precautionary measures for reducing the risks associated with hazardous material spill remediation operations. Failure to adhere to the measures will result in disciplinary action.

Standard safe work and personal hygiene practices that will be followed include:

- Eating, drinking, chewing gum or tobacco, smoking or any activity that increases the probability of hand to mouth transfer and ingestion of material is prohibited in any area designated as contaminated, unless authorized by the Site Health and Safety office.
- Hands and face must be thoroughly washed upon leaving the work area.
- Contact lenses shall not be worn onsite.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.
- Contact with contaminated surfaces suspected of being contaminated should be avoided. Whenever possible, do not walk through puddles, leachate or discolored surfaces, or lean, sit or place equipment on drums, containers or on soil suspected of being contaminated.
- Medicine and alcohol can exacerbate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel on cleanup or response operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Consumption of alcoholic beverages will not be allowed before or during operations.
- Undergarments should be made from natural fibers (i.e., cotton or wool).

### **6.2 Personal Protective Equipment**

It is important that personal protective equipment be appropriate to protect against the potential or known hazards at each cleanup/investigation site. Protective equipment is selected based on the types, concentrations, and routes of personal exposure that may be encountered. In situations where the types of materials and possibilities of contact are unknown or the hazards are not clearly identifiable, a more subjective determination must be made of the personal protective equipment required, based on past experiences and sound safety practices.

In general, levels of personal protection have been determined by the USEPA and are used in selecting equipment for onsite activities. The levels are designated as Level A, B, C, and D. They correspond with the work areas in the exclusion zone and are consistent with the levels of protection described in OSHA 1910.120, Appendix B.

The appropriate level of protection is determined prior to the initial entry based on the best available information. The level of protection anticipated for this site and planned activities is a modification of Level D PPE. Subsequent information, (i.e., sampling results and site observations), may necessitate changes in the original level selected which will be added to specific site safety plans as changes.

#### **6.2.1 Personal Protective Equipment (PPE) Upgrade Rationale**

Pursuant to the air monitoring and screening procedures performed over the course of the RI/FS at the Collierville site and upon review of the constituents identified in TCE spill area, all activities will be performed using modified Level D PPE. This level of protection consists of a hard hat, eye protection (ANSI Z87.1-1968 standard), hearing protection (as necessary), chemical-resistant boots with steel toe and shank, inner nitrile gloves, and outer butyl rubber gloves (for soil sampling in TCE area only). A modified Level D protection was selected because concentrations of the constituents are not expected to reach the action levels prescribed for this site (50 percent of TLV-TWA per constituent). The handling of soil and water samples represent the greatest potential chemical hazards to individuals working on the site. The additional Level D protective clothing and glove was selected for work in the TCE spill area because high concentrations of TCE have been identified in recent groundwater studies at the site.

Air monitoring for organic vapors will be performed during all activities. Instruments will be continuous reading and intrinsically safe. Please refer to Section 7.1 for the specific air monitoring strategy to be employed at the Collierville site.

In the event that activities result in dust or organic vapor levels greater than the prescribed "Action Level," (see Section 5, Table 5-1) PPE will be up graded to Level C. Level C protection consists of one-piece chemical protective coveralls, a full-face, air purifying respirator with volatile organic compound/HEPA combination cartridges, hard hat with full-face shield, butyl rubber outer gloves (resistant to TCE), inner nitrile gloves (resistant to organic solvents), chemical resistant boots with steel toe and shank, and hearing protection (as necessary).

All organic vapor/HEPA combination cartridges will be changed a minimum of once daily. However, water saturation of the HEPA filter or dusty conditions may necessitate more frequent changes. Changes will occur when personnel begin to experience increased inhalation resistance, or breakthrough of a chemical warning property.

Additional PPE upgrades to Level B will be initiated as determined by air monitoring (i.e. in the event that 1 ppm or greater vinyl chloride is measured or if real-time monitoring equipment measures organic vapors in excess of 1000 ppm). See Table 6-1 for the specific criteria for use and equipment for each level of protection.

### **6.2.2 Training**

Training in PPE use is recommended. For respirators, it is required by federal regulation in the OSHA standards in 29 CFR Part 1910. This training:

- Allows the user to become familiar with the equipment in a nonhazardous situation.
- Instills confidence of the user in his/her equipment.
- Makes the user aware of the limitations and capabilities of the equipment.
- Increases the efficiency of operations performed by workers wearing PPE.
- Reduces the expense of PPE maintenance.

Training should be completed prior to actual PPE use in a hazardous environment and should be repeated at least annually. At a minimum, the training portion of the PPE program should delineate the user's responsibilities and explain the following. Both classroom and field training should be used as needed.

- OSHA requirements as delineated in 29 CFR Part 1910.
- The proper use and maintenance of the selected PPE, including capabilities and limitations.
- The nature of the hazards and the consequences of not using the PPE.
- The human factors influencing PPE performance.
- Instruction in inspecting, donning, checking, fitting, and using PPE.
- Individualized respirator fit testing to ensure proper fit.
- Use of PPE in normal air for a long familiarity period and, finally, wearing PPE in a test atmosphere to evaluate its effectiveness.
- The user's responsibility (if any) for decontamination, cleaning, maintenance, and repair of PPE.
- Emergency procedures and self-rescue in the event of PPE failure.
- The buddy system (See Section 3.0, Site Control).
- The site safety plan and the individual's responsibility and duties in an emergency.

The discomfort and inconvenience of wearing PPE can create a resistance to the conscientious use of PPE. One essential aspect of training is to make the user aware of the need for PPE and to instill motivation for the proper use and maintenance of PPE.

Table 6-1 Level of Protection and Criteria		
Level of Protection	Criteria for Use	Equipment
Level A	<ul style="list-style-type: none"> <li>When atmospheres are "immediately dangerous to life and health" (IDLH in the NIOSH/OSHA Pocket Guide to Chemical Hazards or other guides.)</li> <li>When known atmospheres or potential situations exist that would affect the skin or eyes or be absorbed into the body through these surfaces. Consult standard references to obtain concentrations hazardous to skin, eyes or mucous membranes.</li> <li>Potential situations include those where immersion may occur, vapors may be generated or splashing may occur through site activities.</li> <li>When work areas contain less than 19.5% oxygen</li> <li>When the type(s) and or potential concentration of toxic substances are not known.</li> </ul>	<ul style="list-style-type: none"> <li>Pressure-demand, full-facepiece self contained breathing apparatus or pressure-demand, supplied-air respirator with escape SCBA</li> <li>Fully-encapsulating chemical protective suit</li> <li>Chemical-resistant inner and outer gloves</li> <li>Steel toe and shank chemical resistant boots</li> <li>Hard hat under suit</li> <li>Two-way radios worn inside suit</li> <li>Optional: coveralls, long cotton underwear, disposable protective suit, gloves and boots, work over fully encapsulating suit</li> </ul>
Level B	<ul style="list-style-type: none"> <li>In the event colormetric tubes indicate greater than 1 ppm vinyl chloride.</li> <li>In the event real-time monitoring instruments measure organic vapors in excess of 1000 ppm.</li> <li>When work areas contain less than 19.5% oxygen</li> </ul>	<ul style="list-style-type: none"> <li>Chemical resistant clothes, long sleeves, hooded, one or two pieces</li> <li>Full-faced positive-pressure supplied air breathing apparatus or airline system with a 30 minute escape bottle</li> <li>Hard hat</li> <li>Inner gloves and chemical resistant gloves</li> <li>Steel toe and shank boots</li> <li>Coveralls and disposable outer boots</li> </ul>
Level C	<ul style="list-style-type: none"> <li>When the action level (see Table 5-1) as determined by direct reading instrument is measured.</li> <li>When airborne particulate (dust, 5mg/m<sup>3</sup>) warrant respiratory protection</li> <li>When work areas contain at least 19.5% oxygen</li> </ul>	<ul style="list-style-type: none"> <li>Chemical resistant clothes, long sleeves, hood optional, one or two pieces</li> <li>Full-face air purifying respirator equipped with combination HEPA/organic vapor cartridges.</li> <li>Hard hat</li> <li>Inner gloves and chemical resistant gloves</li> <li>Steel toe and shank boots</li> <li>Optional: coveralls and disposable outer boots</li> </ul>
Level D	<ul style="list-style-type: none"> <li>When level B or C is not indicated</li> <li>When airborne particulate do not warrant respiratory protection</li> <li>When work areas contain at least 19.5% oxygen</li> </ul>	<ul style="list-style-type: none"> <li>Inner gloves and chemical-resistant gloves needed to handle soil or water samples</li> <li>Steel toe and shank boots</li> <li>Hard hat (ANSI Z891-1969 standard)</li> <li>Eye protection (ANSI Z87.1-1968 standard)</li> <li>Optional: coveralls and disposable outer boots</li> </ul>

**Notes:**

**Level A** protection will be selected when the highest available level of respiratory, skin, and eye protection is needed. Contraindications for use of Level A are listed below.

- Environmental measures contiguous to the site indicate that air contaminants do not represent a serious dermal hazard.
- Reliable, accurate historical data do not indicate the presence of severe dermal hazards.
- Open, unconfined areas.
- Minimal probability of vapors or liquids (splash hazards) present which could affect or be absorbed through the skin.
- Total vapor readings indicate 500 ppm to 1,000 ppm.

**Level B** protection will be selected when the highest level of respiratory protection is needed, but cutaneous exposure to the small unprotected areas of the body, (neck and back of head) is unlikely, or where concentrations are not known to be within acceptable standards. Additionally, the permissible limit for exposure to mixtures of all site gases will be checked using the requirements of 1910.1000(d)(2)(i) to ensure that PEL is not exceeded. If the value calculated using this method exceeds 1.0, Level B PPE is required.

**Level C** protection will be selected when the types and concentrations of inseparable material is unknown, or reasonably assumed to be no greater than the protection factors associated with air-purifying respirators, and exposure to the unprotected areas of the body is unlikely to cause harm.

Dust Concentrations require Level C PPE where the inspirable (total) dust concentrations as measured by the real-time aerosol monitor exceed the site action level of 5 mg/m<sup>3</sup>.

**Level D** protection will be chosen when measurements of atmospheric concentrations are at background levels and work functions preclude splashes, immersion, or the potential for unexpected inhalation or contact with hazardous levels of any chemicals.

### 6.2.3 Respirator Fit Testing

The "fit" or integrity of the facepiece-to-face seal of a respirator affects its performance. A secure fit is important with positive-pressure equipment, and is essential to the safe functioning of negative-pressure equipment, such as most air-purifying respirators. Most facepieces fit only a certain percentage of the population, thus each facepiece must be tested on the potential wearer in order to ensure a tight seal. Facial features such as scars, hollow temples, very prominent cheekbones, deep skin creases, dentures or missing teeth, and chewing gum and tobacco interfere with the respirator-to-face seal and are not permitted. A respirator will not be worn when such conditions prevent a good seal. The workers' diligence in observing these factors will be evaluated by periodic checks.

For a qualitative respirator fit testing protocol, see Appendix D of the OSHA lead standard (29 CFR Part 1910.1025). For quantitative fit testing, see the NIOSH publication *A Guide to Industrial Respiratory Protection*. For specific quantitative testing protocols, literature supplied by manufacturers of quantitative fit test equipment should be consulted. Note that certain OSHA standards require quantitative fit testing under specific circumstances (e.g., 29 CFR Parts 1910.1018 [h] [3] [iii], 1910.1025 [f] [3] [iii], and 1910.1045 [h] [3] [iii] [B]).

#### **6.2.4 Inspection**

An effective PPE inspection program will probably feature five different inspections:

- Inspection and operational testing of equipment received from the factory or distributor.
- Inspection of equipment as it is issued to workers.
- Inspection after use or training and prior to maintenance.
- Periodic inspection of stored equipment.
- Periodic inspection when a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arise.

Each inspection will cover somewhat different areas in varying degrees of depth. Detailed inspection procedures, where appropriate, are usually available from the manufacturer. The inspection checklists provided in Table 6-2 may also be an aid.

Records must be kept of all inspection procedures. Individual identification numbers should be assigned to all reusable pieces of equipment (respirators may already have ID numbers) and records should be maintained by that number. At a minimum, each inspection should record the ID number, date, inspector, and any unusual conditions or findings. Periodic review of these records may indicate an item or type of item with excessive maintenance costs or a particularly high level of downtime.

#### **6.2.5 Storage**

Clothing and respirators must be stored properly to prevent damage or malfunction due to exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Procedures must be specified for both pre-issuance warehousing and, more importantly, post-issuance (in-use) storage. Many equipment failures can be directly attributed to improper storage.

#### **6.2.6 Clothing**

- Potentially contaminated clothing should be stored in an area separate from street clothing.
- Potentially contaminated clothing should be stored in a well-ventilated area, with good air flow around each item, if possible.



Table 6-2 PPE Maintenance Checklist		
Category	Before Use	During and After Use
Clothes	<ul style="list-style-type: none"> <li>• Make sure that the clothes are correct for the task.</li> <li>• Visually check for imperfect seams, tears, nonuniform coatings, malfunctioning closures.</li> <li>• Hold up to light and check for pinholes.</li> <li>• Flex product, check for cracks, other signs of deterioration.</li> <li>• If used, check inside and out for signs of chemical attack: discoloration, swelling, stiffness.</li> </ul>	<ul style="list-style-type: none"> <li>• During use: periodically check for evidence of chemical attack such as discoloration, swelling, and softening. Keep in mind that chemical permeation can occur with visible effects.</li> <li>• Also check for: closure failure, tears, punctures, seam discontinuities.</li> </ul>
Gloves	<ul style="list-style-type: none"> <li>• Pressurize glove to check for pinholes: Either blow into glove, then roll gauntlet towards fingers or inflate glove and hold under water. In either case, no air should escape.</li> </ul>	_____
Fully-encapsulating suits	<ul style="list-style-type: none"> <li>• Check the operation of pressure relief valves.</li> <li>• Check the fitting of wrists, ankles and neck.</li> <li>• Check the faceshield (if equipped with one) for: cracks, crazing, fogginess.</li> </ul>	_____
Self-contained breathing apparatus	<ul style="list-style-type: none"> <li>• Check before and after use, at least monthly when in storage, and each time cleaned:</li> <li>• Check connections for tightness</li> <li>• Check material for signs of pliability, deterioration, distortion</li> <li>• Check for proper setting and operation of regulators and valves</li> <li>• Check operation of alarms</li> <li>• Check faceshields and lenses for cracks, crazing, fogginess</li> </ul>	<ul style="list-style-type: none"> <li>• After use, store SCBAs in storage chests supplied by manufacturer.</li> </ul>

Table 6-2 PPE Maintenance Checklist		
Category	Before and During Use	After Use
Supplied-air respirators	<ul style="list-style-type: none"> <li>• Inspect daily when in use, at least monthly when in storage, and every time cleaned.</li> <li>• Inspect air prior to each use for cracks, kinks, cuts, frays and weak areas.</li> <li>• Check for proper setting and operation of regulators and valves.</li> <li>• Check connections for tightness.</li> <li>• Check material for pliability, deterioration, distortion.</li> <li>• Check faceshields and lenses for cracks, crazing, fogginess.</li> </ul>	<ul style="list-style-type: none"> <li>• Inspect at least monthly when in storage using the same criteria as listed under:  Before and During Use</li> </ul>
Air-purifying respirators	<ul style="list-style-type: none"> <li>• Inspect before use to be sure they have been adequately cleaned, after each use, during cleaning, monthly if in storage.</li> <li>• Check material for pliability, deterioration, distortion.</li> <li>• Check cartridges or canisters to make sure: They are the proper type for the intended use, the expiration date has not passed, and they have not been opened or used previously.</li> <li>• Check faceshield and lenses for cracks, crazing, fogginess.</li> </ul>	<ul style="list-style-type: none"> <li>• Each air purifying respirator should be stored in its original carton or carrying case or in heat sealed or resealable plastic bag.</li> <li>• Each respirator should be stored individually.</li> </ul>

- Different types and materials of clothing and gloves should be stored separately to prevent issuing the wrong material by mistake.
- Protective clothing should be folded or hung in accordance with manufacturer's recommendations.

#### 6.2.7 Respirators:

- SCBAs, supplied-air respirators, and air-purifying respirators should be dismantled, washed, and disinfected after each use.

### **6.3 Maintenance**

The technical depth of maintenance procedures vary. Manufacturers frequently restrict the sale of certain PPE parts to individuals or groups who are not specially trained, equipped, and "authorized" by the manufacturer to purchase them. Explicit procedures should be adopted to ensure that the appropriate level of maintenance is performed only by individuals having this specialized training and equipment. The following classification scheme is often used to divide maintenance into three levels:

- Level 1:** User or wearer maintenance, requiring a few common tools or no tools.
- Level 2:** Shop maintenance that can be performed by the employer's maintenance shop.
- Level 3:** Specialized maintenance that can be performed only by the factory or an authorized repair person.

See Table 6-2 for a PPE Inspection Checklist which provides guidelines for maintenance of equipment.

### **6.4 Safety Equipment**

All site personnel must be adequately protected from potential health and safety hazards. Therefore, a sufficient and diverse inventory of all safety equipment necessary to meet anticipated hazards will be available to all employees. Personnel and site visitors must be instructed in the proper use of this equipment before entry to the work area is permitted. A list of all safety equipment available at the site will be maintained and incorporated into the specific site safety plan. The list will include first aid, firefighting, communications, respiratory protection, protective clothing (suits, gloves, boots, hard hats, goggles, etc.) and monitoring equipment.

### **6.5 Procedures and Equipment for Extreme Weather Conditions**

Field activities for this site are scheduled to last two to three years. Therefore, both heat and cold stress will be concerns for the health and safety personnel. Adverse weather conditions are important considerations in planning and conducting site operations. Extremes in hot and cold weather can cause physical discomfort, loss of efficiency and personal injury.

#### **6.5.1 Heat Stress**

Heat stress can result when the protective clothing decreases natural body ventilation even when temperatures are moderate. Working under various levels of personal protection may require

wearing low permeability disposable suits, gloves and boots which prevent most natural body ventilation. Discomfort due to increased sweating and body temperature (heat stress) will therefore be expected at the work site.

Heat stress is the metabolic and environmental heat to which an individual is exposed. Heat strain is the adjustment made by an individual in response to the stress. The three most important categories of heat-induced illness are: heat exhaustion, heat cramps, and heat stroke. These disorders can occur when the normal responses to increased sweat production are not adequate to meet the needs for body heat loss or when the temperature-regulating mechanisms fail to function properly.

**Heat exhaustion** is a state of collapse brought about by an insufficient blood supply to the cerebral cortex portion of the brain. The crucial event is low blood pressure caused by inadequate heart output and widespread expansion of blood vessels.

There are three significant factors which can lead to heat exhaustion:

- Increased expansion of blood vessels which causes a decreased capacity of circulation to meet the demands for heat loss due to the environment, exercise, and digestive activities.
- Decreased blood volume due to dehydration.
- Reduced blood volume due to lack of physical training, infection, intoxication (from industrial contaminants as well as from drinking alcohol), or heart failure.

The symptoms include extreme weakness or fatigue, dizziness, nausea, or headache. More severe cases may also involve vomiting and possible unconsciousness. The skin becomes clammy and moist, the complexion pale, and the oral temperature stays normal or low but the rectal temperature is usually elevated (99.5°F - 101.3°F). Workers who are unacclimated run the highest risk.

In most cases, treatment of heat exhaustion is fairly simple. The victim will be moved to a cool place. If the victim is unconscious, medical assistance must be sought. Victims with mild cases of heat exhaustion may experience immediate recovery; however, more severe cases may require several days of care. No permanent effects have ever been reported.

**Heat cramps** result when the working muscles go into painful spasms. Heat cramps may occur in those who perspire profusely in heat and who drink large quantities of water, but fail to replace their bodies' low salt. It is the low salt content in the blood that causes the cramping. The abdominal muscles as well as the muscles in the arms and legs may be affected. The cramps may appear during or even after work hours. Victims of heat cramps who are on a low

sodium diet should not be given salt. A physician must be consulted on the care of people with this condition.

**Heat stroke** is the most serious of the health problems that arise while working in hot environments. It is caused by the breakdown of the thermoregulatory system under stress. When this happens, perspiration stops and the body can no longer regulate its own temperature.

Heat stroke victims must be treated as a major medical emergency. A heat stroke victim may be identified by hot, dry, and usually red or spotted skin. The body core temperature can exceed 105°F. Mental confusion, irritability and chills are common symptoms of heat-stroke victims. These symptoms are all early warning signs of heat stroke; if the sufferer is not removed from the hot environment at once, more severe symptoms can follow, including unconsciousness, delirium, and convulsions, possibly ending in death.

When someone is suffering from heat stroke, medical assistance must be summoned immediately. In addition:

- First aid must be administered
- Individual must be moved to a cool location
- Individual must be cooled through wetting, fanning, or immersion

Early recognition and treatment of heat stroke are the only means of preventing permanent brain damage or death. Care should be taken to avoid over-cooling. Treatment for shock should be given by raising the victim's legs.

Recommendations to reduce heat stress are:

- Drink plenty of fluids (to replace loss through sweating).
- Wear cotton undergarments to act as a wick to absorb moisture.
- Make adequate shelter available for taking rest breaks to cool off.

In extremely warm weather, the site health and safety officer may also require these additional measures:

- Wear cooling devices to aid in ventilation (NOTE: the additional weight may affect efficiency).
- Install portable showers or hose down facilities to cool clothing and body.
- Shift working hours to early morning and early evening. Avoid the hottest time of the day.
- Frequently rotate crews wearing the protective clothing.

An emergency medical technician is present on each shift to monitor personnel for signs of heat stress and to keep a record of the individual's body temperature, blood pressure, pulse rate, and fluid intake for each work day (See example log in Figure 6.1). These records will be maintained as a permanent part of the site personnel's medical file and retained for the same time period as the medical record.

### 6.5.2 Cold Exposure

Persons working outdoors in temperatures at or below freezing may experience frostbite or hypothermia. Extreme cold for a short time may cause severe injury to the surface of the body. Areas of the body that have a high surface-area-to volume ratio, such as fingers, toes, and ears are the most susceptible.

Two factors influence the development of cold injury: Ambient temperature and the velocity of the wind. As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus the body cools suddenly when protective equipment is removed if the clothing underneath is soaked with perspiration.

**Frostbite** is a condition in which the cold forms ice crystals in the cells and tissues, dehydrating protoplasm and killing tissues. At the same time, circulation of the blood is blocked. Frostbite could lead to gangrene and amputation.

Frostbite damage occurs in several degrees:

- Frost nip, or incipient frostbite, is characterized by sudden blanching or whitening of the skin.
- When superficial frostbite occurs, the skin has a waxy or whitish look and is firm to the touch; however, the tissue underneath has retained its resiliency.
- In deep frostbite, the tissues are cold, pale, and solid. The injury is severe.

In addition to frostbite, other physiological reactions to cold may be experienced as well. Trench foot, for example, may result from prolonged exposure to low temperatures near, though possibly above, freezing. Walking on the foot is very painful. In very severe cases, the flesh dies and the foot may have to be amputated. Immersion foot is very similar although it is less severe. Although amputation is unusual, some mobility of the limb is lost.

Blisters may occur around the lips, nostrils and eyelids.

**Figure 6.1**  
**Individual Heat Stress Monitoring Log**

Name \_\_\_\_\_ Date \_\_\_\_\_ Shift \_\_\_\_\_

	START OF SHIFT	MID- SHIFT	END OF SHIFT
AMBIENT AIR TEMPERATURE (°F)			
PULSE RATE			
BODY TEMPERATURE (°F)			
BLOOD PRESSURE			
WEIGHT (POUNDS)			
FLUID INTAKE (IN OUNCES)			

**Chilblain (pernio)** which is an inflammation of the hands and feet caused by exposure to cold and moisture, is characterized by a recurrent localized itching, swelling, and painful inflammation on the fingers, toes, or ears, produced by mild frostbite. Such a sequence produces severe spasms, accompanied by pain.

**Hypothermia** occurs when the body loses heat faster than it can produce it. The initial reaction involves the constriction of blood vessels in the hands and feet in an attempt to conserve the heat. After the initial reaction, involuntary shivering begins in an attempt to produce more heat.

Temperature is only a relative factor in cases of hyperthermia. Cases of exposure have occurred in temperatures well above freezing. Humidity is another important factor. Moisture on the skin and clothing will allow body heat to escape many times faster than when the skin and clothing are dry.

Hypothermia occurs when the body's core temperature drops below 96°F. When this happens, the affected person becomes exhausted. He may begin to behave irrationally, move more slowly, stumble and fall. The speech becomes weak and slurred. If these preliminary symptoms are allowed to pass untreated, stupor, collapse, and unconsciousness occur, possibly ending in death.

Recommendations to reduce effects of cold exposure:

- Stay dry. When the temperature drops below 40°F, change perspiration soaked clothes frequently. When clothes get wet, they lose about 90 percent of their insulating value.
- Beware of the wind. A slight breeze carries heat away from bare skin much faster than still air. Wind drives cold air under and through clothing. Wind refrigerates wet clothes. Wind multiplies the problems of staying dry.
- Understand cold. Most hypothermia cases develop in temperatures between 30°F and 50°F. Cold water running down the neck and legs or cold water held against the body by sopping clothes causes hypothermia.
- Make adequate dry, warm shelter available.
- Provide warm drinks.

Never ignore shivering. Persistent shivering is a clear warning that a person is on the verge of hypothermia. Allow for the fact that exposure greatly reduces normal endurance. Physical activity may be the only factor preventing hypothermia.

## **6.6 Work Limitations**

All site activities will be conducted during daylight hours only. All personnel scheduled for these activities will have completed initial health and safety training and actual field training as



specified in 29 CFR 1910.120. All supervisors must complete an additional eight hours of training in site management. All personnel must complete an eight hour refresher training course on an annual basis in order to continue working at this site.

## **6.7 Exposure Evaluation**

All personnel scheduled for site activities will have a baseline physical examination which will include a physical examination, stressing examination of the neurologic, cardiopulmonary, musculoskeletal and dermatological systems, pulmonary function testing, multi-chemistry panel and urinalysis and be declared fit for duty. An exposure history form will be completed for each worker participating in site activities. An examination and updated occupational history will be repeated on an annual basis and upon termination of employment as required by 29 CFR 1910.120(f). The content of the annual/termination examination will be the same as the baseline physical. A qualified physician will review the results of the annual examination and exposure data and request further tests or issue medical clearances as appropriate.

After any job-related injury or illness, there will be a medical examination to determine fitness for duty or for the need for any job restrictions. The site health and safety officer will review the results with the examining physician prior to releasing the employee for work. A similar examination will be performed if an employee has missed at least three days of work due to a non-job related injury or illness requiring medical attention.

Medical records shall be maintained by the employer or the physician for at least thirty (30) years following the termination of employment.

## 7.0 MONITORING REQUIREMENTS

### 7.1 Air Monitoring

Air monitoring for volatile organic compounds (VOCs), and total dust will be performed continuously during all site activities that occur within the TCE spill area and during all monitoring well installation activities. Instruments will be continuous reading and intrinsically safe. Personnel air monitoring shall also be performed to determine exposure levels of personnel performing site sampling and investigation procedures. Personnel air samples will be collected and analyzed with respect to NIOSH Manual of Analytical Methods, 1984, as required per 29 CFR 1910.1000. Personnel samples will be collected during each site activity in which Level C PPE is prescribed. Additional personnel samples will be collected during site activities that are predicted to represent worst case exposure potential. In each case where real time monitoring instruments indicate the need to upgrade PPE, personnel monitoring will be conducted. The chemical constituents that will be targeted are trichloroethylene, 1,1 dichloroethylene, vinyl chloride, 1,2-dichloroethylene, tetrachloroethylene, lead and total dust.

Air monitoring for VOCs will be accomplished using a photoionization detector. This instrument will be used daily to determine background levels of VOCs prior to initiating any onsite activities and during all surface soil sampling, subsurface soil borings and groundwater monitoring well installations. The site action level for upgrading to Level C PPE is 5 ppm above the measured background VOC concentration as measured prior to the initiation of the daily activities. If the measured background level is consistently above 2 to 3 ppm, NIOSH approved methods or direct reading colorimetric absorbent tubes will be used to determine the chemical constituents of the measured background VOCs. The logic here is that while the primary contaminant at this site is TCE, vinyl chloride is extremely toxic and must be monitored for.

Instruments will be continuous-reading and equipped with alarms. Each instrument will be calibrated before site activities begin each day and at the end of each day's activities. Before calibration at the end of the day, each instrument will be checked for surface contamination.

VOC — HNU Tip Photoionization Detector NIOSH Method 1022 (Sorbent Sample Tubes to be used when VOC are greater than 5ppm over background).

Inspirable Miniram Personal Monitor, Model PDM-3 Dust

In the event of a PPE upgrade or if the site activities are ceased, the EPA will be notified within 24 hours. A log of all air monitoring activities will be maintained in the EnSafe office. This log will indicate the date and time of the readings, the location, the activity that is performed in the area where the readings were taken, the concentrations observed on the instruments, the

types of instruments used, and the signature of the person taking the readings. A copy of the most current log sheet will be posted in the decontamination station and copies of all log sheets will be made available to any site employee upon request.

Table 7-1 on the following page presents a summary of exposure guidelines for expected site chemicals.

Air monitoring will be conducted by the shift supervisor prior to the start of each shift and during the mid-point of each shift. Air monitoring will be conducted at locations that will provide the most effective measurement of all gases. Results of the current air monitoring will be posted in the decontamination station and all logs are available to any worker or representative as well as to regulatory agencies.

## **7.2 Confined Space Entry Procedures**

There should be no confined space entry work completed at this site during remedial design.

<p style="text-align: center;"><b>Table 7-1</b>  <b>Exposure Guidelines for Site Chemical Hazards</b></p>					
<b>Chemical Name</b>	<b>Odor Threshold (ppm)</b>	<b>OSHA PEL (ppm) <sup>1</sup></b>	<b>ACGIH TLV (ppm) <sup>2</sup></b>	<b>NIOSH REL (ppm) <sup>3</sup></b>	<b>Site Action Levels <sup>5,6</sup></b>
Trichloroethylene (TCE)	50 ppm	50 ppm 200 Ceiling	50 TWA 200 STEL	25 ppm	25 ppm (5 ppm)
1,1-Dichloroethylene	500 ppm	1 ppm	5 TWA 20 STEL	—	0.5 ppm (5 ppm)
Vinyl chloride	3000 ppm	1 ppm 5 ppm Ceiling	1 ppm 5 ppm Ceiling	Lowest Feasible Concentration	0.5 ppm (5 ppm)
1,2-Dichloroethylene	6.0-10.0 ppm	200 ppm	200 ppm	200 ppm	100 PPM (5 ppm)
Tetrachloroethylene	—	25 ppm 200 Ceiling	50 TWA 200 STEL	Lowest Feasible Concentration	12.5 PPM (5 ppm)
Total Dust	—	15 mg/m <sup>3</sup>	10 mg/m <sup>3</sup>	—	5 mg/m <sup>3</sup>
Lead	—	0.05 mg/m <sup>3</sup> 0.03 (Action Level)	0.15 mg/m <sup>3</sup>	0.10 mg/m <sup>3</sup>	0.03 mg/m <sup>3</sup>

**Notes:**

- 1 29 CFR 1910.1000, Table Z-1-A. Limits For Air Contaminants, as amended through 1/15/91.
- 2 1990 - 1991 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH
- 3 NIOSH Pocket Guide to Chemical Hazards, September 1985
- 4 Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989, Range of All Reference Values
- 5 Site Action Levels calculated as 50% pf TVL or PEL (as measured by NIOSH methods) - whichever is lower
- 6 Site Action levels for VOCs as measured by Real Time Photoionization detector = 5 ppm

## **8.0 DECONTAMINATION**

A decontamination zone will be established at the work site entrance which will include an area for sampling equipment and personnel decontamination.

### **8.1 Personnel Decontamination**

The decontamination procedures, based on Level C or D protection, will consist of:

- Brushing heavily soiled boots and rinsing outer gloves and boots with soap and water.
- Removing outer gloves depositing them in a plastic lined container.
- Washing and rinsing safety suit and respiratory protection equipment (facepiece, etc.)
- Removing safety suit, and boots. Safety suits are to be deposited in a plastic lined container.
- Washing and rinsing inner gloves, removing facepiece, washing and rinsing inner gloves and removing inner gloves. Facepieces will be decontaminated and cleaned for reuse, inner gloves will be deposited in a plastic lined container.
- Respiratory protection equipment will be inspected and serviced as needed prior to next use.

Decontamination procedures will be conducted at the lunch break and at the end of each work day. If the field activities zone is left at other times during the work day, contaminated clothing will be left at the decontamination station on plastic sheeting to be reworn on returning.

If higher or lower levels of protection are needed, adjustments will be made to these procedures and an amendment will be made to this health and safety plan.

### **8.2 Equipment Decontamination**

All equipment leaving the Exclusion Zone should be decontaminated to prevent the offsite migration of hazardous contaminants. In addition, all equipment used at the site should be decontaminated upon completion of the project.

In limiting the potential environmental exposures, the following procedures should be used:

- All contaminated surfaces should be washed with a 5% trisodium phosphate (TSP) solution
- All surfaces should then be rinsed with water; all rinsate will be retained onsite in a holding tank. Rinsate will be sampled and analyzed for full TCL/TAL per the site Quality Assurance Plan
- Heavy equipment will be steam cleaned with an industrial soap solution (5% TSP) and then be allowed to air dry onsite.

### **8.3 Closure of the Personnel Decontamination Station**

All disposable clothing and plastic sheeting used during site activities will be double-bagged and disposed of in a refuse container. Decontamination and rinse solutions will be collected in 55-gallon drums. Reusable clothing will be dried and prepared for future use. All washtubs, pails, buckets, etc. will be washed, rinsed and dried at the end of each workday.

## **9.0 AUTHORIZED PERSONNEL/RESPONSIBILITIES**

Only those personnel authorized by EnSafe and Carrier will be allowed onsite.

### **9.1 Responsibilities of the EnSafe Site Manager**

The site manager will direct the site investigation and operation and is responsible for the following.

1. Assuring that all personnel are aware of:
  - Names of personnel and alternates responsible for site safety and health
  - Safety, health and other hazards present on the site
  - Use of personal protective equipment and assuring that the equipment is available.
  - Work practices which can minimize risks from hazards
  - Safe use of engineering controls and equipment on the site
  - Medical surveillance requirements including recognition of symptoms and signs which might indicate over-exposure to hazards
  - Site control measures, decontamination procedures, site standard operating procedures and the contingency plan and responses to emergencies including the necessary PPE.
2. Assuring that all employees have received a minimum of 40 hours of health and safety instruction, off the site, and actual field experience under the direct supervision of a trained experienced supervisor. Workers who may be exposed to unique or special hazards will be provided additional training.
3. Monitoring the performance of personnel to ensure that mandatory health and safety procedures are being performed and correcting any performances that do not comply with the health and safety plan.
4. Ensuring that all field personnel employed on the site are covered by a medical surveillance program as required by 29 CFR 1910.120(f).
  - Consulting with the health and safety officer and/or other personnel.
  - Preparing and submitting project reports, including progress, accident, incident, contractual, etc.
  - Monitoring personnel decontamination to ensure that all personnel are complying with the established decontamination procedures.

## 9.2 Responsibilities of the Site Health and Safety Officer

- Assure that a copy of the health and safety plan is maintained onsite during all field activities.
- Advise the project manager on all health and safety related matters involved at the site.
- Direct and ensure that the safety program is being correctly followed in the field, including the proper use of personal protective and site monitoring equipment.
- Ensure that the field personnel observe the appropriate work zones and decontamination procedures.
- Report any safety violations to the project manager.
- Conduct or schedule safety briefings during field activities. The following items Table 9-1 will be discussed by a qualified individual at the site pre-entry briefings, as well as daily or periodic site briefings.

Table 9-1 Items to be Discussed at Safety Briefings	
Frequency	Items to be discussed
Daily	<ul style="list-style-type: none"><li>• Site Chemical Hazards</li><li>• Air Monitoring</li><li>• Location and Use of Emergency Equipment</li></ul>
Monthly	<ul style="list-style-type: none"><li>• Site Chemical Hazards</li><li>• Use of Supplied Air Breathing Apparatus</li><li>• Use of Air Purifying Respirators</li><li>• Air Monitoring</li><li>• Structural Monitoring</li><li>• Location and Use of Emergency Equipment</li></ul>
Seasonal	<ul style="list-style-type: none"><li>• Heat Stress</li><li>• Cold Exposure</li></ul>
Quarterly	Decontamination Procedures
Semi-annually	Confined Space Entry

Initially, the site health and safety officer will be a person trained in safety and industrial hygiene. After the project begins and the site safety officer has had time to evaluate actual hazardous site conditions, he/she may determine that a member of the project team may assume



the duties of daily duties of the site health and safety officer. These duties would likely include daily meetings, and collection and interpretation of air monitoring data.

The person responsible for daily health and safety will be trained to use the air monitoring equipment, interpret the data collected with the instruments and be familiar with symptoms of heat stress and cold exposure and thoroughly familiar with the location and use of safety equipment on site. He will also be familiar with this health and safety plan.

The following criteria outline when the site health and safety officer will be replaced: (1) Termination of Employment, (2) Sickness, (3) End of Shift, (4) Injury, or (5) Death. It should be noted that under revised site work schedules only one shift will be working. As a result, the site HSO will be responsible for the day shift. Should circumstances arise that require work during other periods, an alternate site HSO will be designated.

### **9.3 Responsibilities of Onsite Field Personnel**

- All personnel going on the site must be thoroughly briefed on anticipated hazards and trained on equipment to be worn, safety procedures to be followed, emergency procedures and communications.
- Required respiratory protective devices and clothing must be worn by all personnel going into areas designated for wearing protective equipment.
- Personnel must be fit-tested prior to use of respirators.
- No facial hair which intrudes on the sealing surface of the respirator is allowed on personnel when respiratory protection is required.
- Personnel on the site must use the buddy system when wearing respiratory protective equipment. As a minimum, a third person, suitably equipped as a safety backup, is required during all entries.
- Visual and/or radio contact must be maintained between pairs onsite and the site safety personnel. Field personnel should remain close together to assist each other during emergencies.
- All field personnel should make use of their senses to alert themselves to potentially dangerous situations which they should avoid, e.g., presence of strong and irritating or nauseating odors.
- Personnel must practice unfamiliar operations before implementation in the field.

- Field personnel will be familiar with the physical characteristics of the site:
  - wind direction in relation to contamination zones
  - accessibility to associates, equipment and vehicles
  - communications
  - operation zones
  - site access
  - nearest water sources
- The number of personnel and equipment in the contaminated area must be kept to a minimum, consistent with effective site operations.
- Procedures for leaving a contaminated area must be planned and implemented before going onsite according to the health and safety plan.
- All visitors to the job site must comply with the health and safety plan procedures. Personal protection equipment may be modified for visitors depending on the situation. Modifications must be approved by the site health and safety officer.

## 10.0 EMERGENCY INFORMATION

All hazardous waste site activities present a potential risk to onsite personnel. During routine operations, risk can be kept to a minimum by establishing good work practices, staying alert and using proper personal protective equipment. Unpredictable events such as physical injury, chemical exposure or fire may occur and must be anticipated.

If any situation occurs that requires outside services, EnSafe will contact Carrier's representative, Mr. Doug Bailey, and make appropriate contacts from Table 10-1:

Table 10-1 Emergency Contact List		
Contact	Person or Agency Name	Telephone Number
Carrier Collierville	Mr. Douglas A. Bailey Mr. Carl Krull	(315) 433-4248 (901) 854-3279
Law Enforcement	Collierville Police Department	(901) 853-3207 or 911
Fire Department	Collierville Fire Department	(901) 853-3223 or 911
Poison Control Center	Southern Poison Control	(901) 528-6048
CHEMTREC		(800) 424-9300
EnSafe Site Manager	Mr. Craig Wise	(901) 372-7962
EPA Region IV	Ms. Beth Brown	(404) 347-7791
EnSafe Inc.	Mr. Phil Coop	(901) 372-7962
Primary Hospital Emergency	Germantown Community Hospital/Methodist East	(901) 757-6622 or 911
Site Command Post	EnSafe	(901) 483-0824

## 10.1 Site Resources

A telephone for emergency use will be available at the command post. Additionally, portable telephones will be available at each work area that is remote from the command post. First aid equipment, including eye wash facilities, will be available at the command post. Restrooms and water will be located in the plant.

## **10.2 Pre-Emergency Planning**

During the site briefings that are held daily and also at special periodic meetings, all employees will be trained in and reminded of the provisions of the emergency response plan, communications systems, and evacuation routes. This plan will be reviewed and revised if necessary, on a regular basis by the EnSafe Health and Safety Officer to ensure that the plan is adequate and consistent with prevailing site conditions.

## **10.3 Personnel Roles and Lines of Authority**

The EnSafe Site Manager and response contractor will have primary responsibility for responding to and correcting emergency situations. This includes taking appropriate measures to ensure the safety of site personnel and the public. Possible actions may involve evacuation of personnel from the site area, and evacuation of adjacent residents. These managers are additionally responsible for ensuring that corrective measures have been implemented, appropriate authorities are notified, and follow up reports completed as required by OSHA 29 CFR 1904. The EnSafe Health and Safety Officer may be called upon to act on the behalf of the site supervisors, and will direct responses to any medical emergency. The individual contractor organizations are responsible for assisting the EnSafe Site Manager in the performance of his/her mission within the parameters of their scope of work.

EnSafe Site Manager	Mr. Craig Wise
EnSafe Site Representative	Mr. Ted Blahnik
EnSafe Site Health and Safety Officer	Mr. John Borowski, CIH
Alternate Shift Health and Safety Officers	Mr. Craig Wise Mr. Ted Blahnik
Personnel with American Red Cross Standard First Aid Training and Adult CPR Training	Mr. Ted Blahnik Mr. John Borowski Mr. Craig Wise

**Note: The Site Health and Safety Manager shall submit an Accident Report Form to the EPA within 24 hours of an incident.**

#### 10.4 Evacuation Routes/Procedures

In the event of an emergency which necessitates an evacuation of the site, the following alarm procedures will be implemented:

The evacuation alarm is a constant sounding of the air horn. The procedures to be followed when the air horn is heard are:

When the evacuation alarm is sounded, **STOP WORK**. Keep calm, think, avoid panic and confusion. Move to the nearest safe exit in your area.

When evacuating the area, **WALK** to the nearest safe exit. **DO NOT RUN**, nor **LINGER** in entrance ways or roadways.

**LEAVE** the area and report to your designated assembly area, or to a safe area away from the incident if no assembly area has been designated. **REPORT** to your supervisor as soon as you arrive at the assembly area and follow his/her instructions.

**STAY** outside the affected area until notified by your shift supervisor that it is safe to reenter.

Each supervisor must conduct a **HEAD COUNT** and report to the EnSafe Site Manager when all of his/her employees have cleared the area and notify the EnSafe Site Manager if anyone is missing.

All personnel will **REMAIN** at the assembly area until directed to another location by the shift supervisor or the EnSafe Site Manager or the Re-entry signal is sounded. The Re-entry signal is an intermittent sounding of the siren. The primary assembly area is the decontamination station. The secondary assembly area is the EnSafe office trailer. The secondary assembly will be used only when directed by the shift supervisor or the EnSafe Site Manager. Figure 10.1, Emergency Facilities Plan, depicts the locations of assembly areas and emergency equipment. Figure 10.2 shows the route to the Germantown Community Hospital.

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**EN SAFE** <sup>SM</sup>

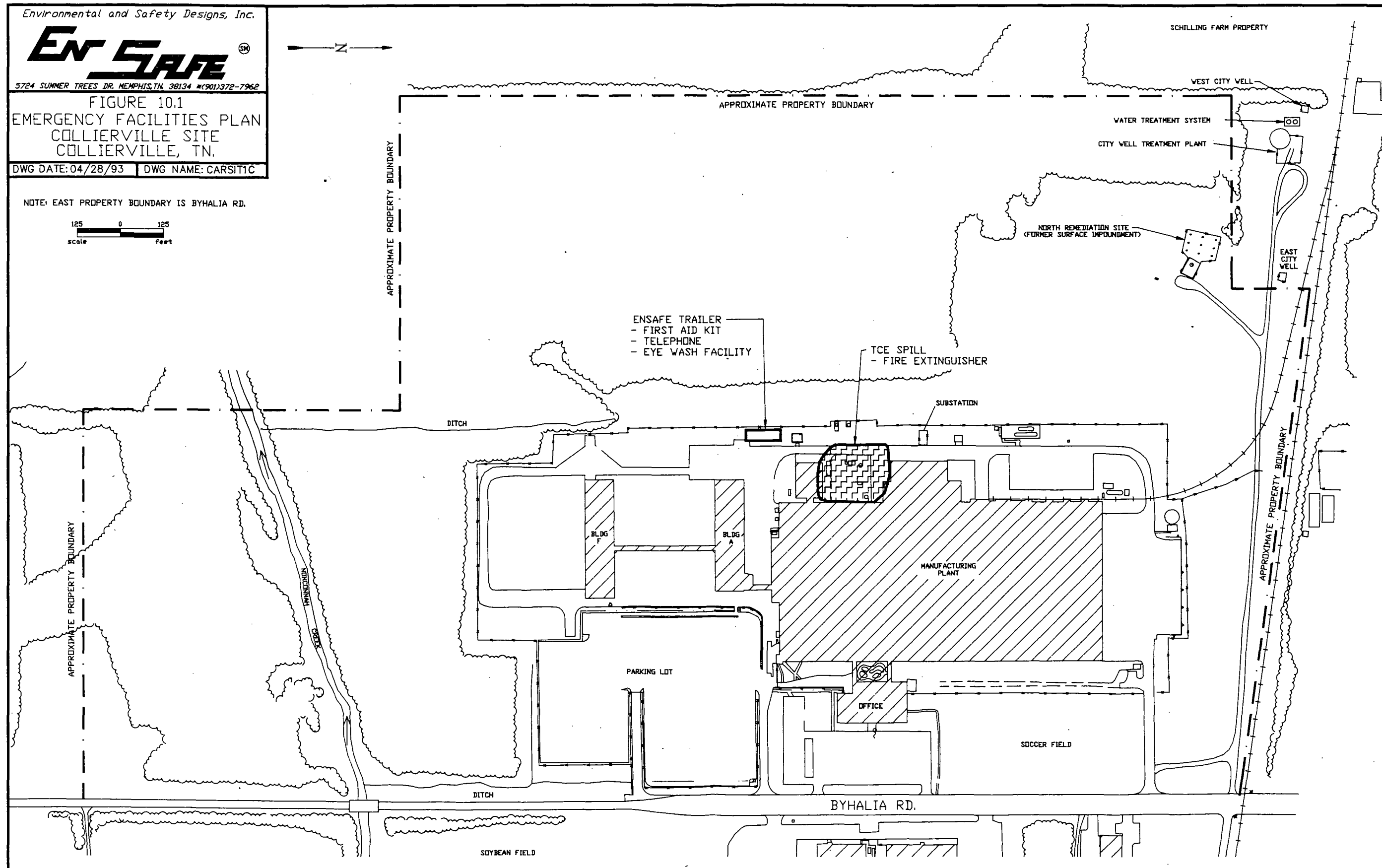
5724 SUMMER TREES DR. MEMPHIS, TN 38134 (901)372-7962

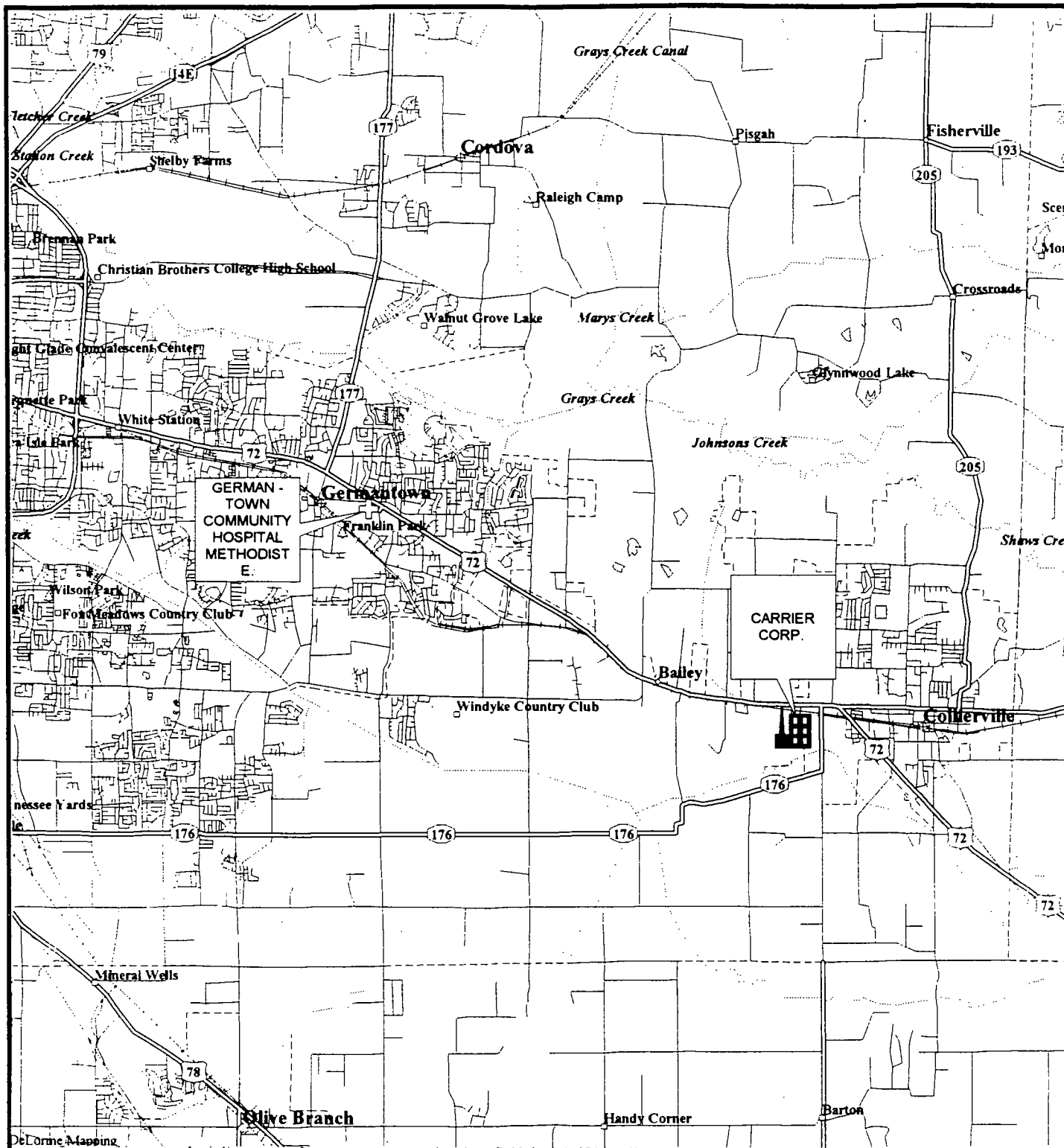
FIGURE 10.1  
EMERGENCY FACILITIES PLAN  
COLLIERVILLE SITE  
COLLIERVILLE, TN.

DWG DATE: 04/28/93 DWG NAME: CARST1C

NOTE: EAST PROPERTY BOUNDARY IS BYHALIA RD.

125 0 125  
scale feet





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**ENSAFE** SM

5724 SUMMER TREES DR. MEMPHIS, TN 38134 (901) 372-7962

FIGURE 10.2  
ROUTE TO  
GERMANTOWN COMMUNITY HOSPITAL

DWG DATE: 04/30/93

DWG NAME: BOARD

## **10.5 Location of the Nearest Hospital Capable of Treating Chemical Exposures**

Germantown Community Hospital/Methodist East  
7691 Poplar Avenue  
Germantown, Tennessee

**Emergency Room Telephone Number - (901) 757-6622**

### **Directions to Germantown Community Hospital/Methodist East from Carrier Collierville:**

- 1) Exit Site to the right (north) onto Byhalia Road.
- 2) Turn right (west) at the first red light onto Poplar Avenue (Highway 72 West).
- 3) Proceed for approximately 6 to 7 miles.
- 4) The emergency entrance to the hospital is on the left.

## **10.6 Emergency Contact/Notification System**

Table 10-1 provides names and telephone numbers for emergency contact personnel. In the event of a medical emergency, personnel will take direction from the EnSafe Health and Safety Officer or his representative and notify the appropriate emergency organization. In the event of a fire or spill, the shift supervisor will notify the appropriate local, state, and federal agencies.

## **10.7 Emergency Medical Treatment Procedures**

Any person who becomes ill or injured in the exclusion zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed (i.e., complete disrobing of the victim and redressing in clean coveralls or wrapping in a blanket). First aid should be administered while awaiting an ambulance or paramedics. All injuries and illnesses must immediately be reported to the shift supervisor, and the EnSafe Site Manager.

Any person being transported to a clinic or hospital for treatment should take with them information on the chemical(s) they have been exposed to at the site or should be accompanied by a person who can provide this information.

Any vehicle used to transport contaminated personnel will need to be decontaminated as necessary.



## **10.8 Fire or Explosion**

In the event of a fire or explosion, the local fire department will be summoned immediately. Upon their arrival, the shift supervisor or site manager will advise the fire commander of the location, nature, and identification of the hazardous materials onsite.

If it is safe to do so, site personnel may:

- Use fire fighting equipment available onsite to control or extinguish the fire;
- Remove or isolate flammable or other hazardous materials which may contribute to the fire.

If it is not safe to take the above actions, the work area must be evacuated.

## **10.9 Spills or Leaks**

In the event of a spill or leak, site personnel will:

- Inform the supervisor immediately;
- Locate the source of the spillage and stop the flow if it can be done safely;
- Begin containment and recovery of the spilled materials.
- Notify EPA

## **10.10 Emergency Equipment/Facilities**

Figure 10.1 provides a map of the site and identifies the location of the following emergency equipment:

- First Aid Kits
- Telephones
- Eye Wash Stations

## **11.0 CONTINGENCY PLAN**

The following Contingency Plan is designed to minimize the hazards of human health and the environment as a result of unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents from the Carrier Collierville Site as specified in 40 CFR 264, Subpart D.

This plan will identify key personnel and their roles in an Incident Command System which will be activated in the event of unforeseen conditions (fire, explosion) or waste that results in the release of hazardous waste or hazardous waste constituents from the Carrier Collierville site. Additionally, this plan identifies the response organizations and precisely how they will be notified in the event of a release or emergency. Also outlined are emergency procedures regarding site evacuation, hazard assessment, and emergency equipment.

### **11.1 Incident Command System**

The Incident Command System (ICS) is designed to provide an instant command system to address the various duties required to effectively and efficiently manage an event and or release of hazardous materials. The following ICS positions are identified and their roles clearly defined.

**Incident Commander** shall assume immediate responsibilities to coordinate activities and communications, including:

- Notification of Response Center, and Federal, State and Local authorities.
- Alert members of the ICS
- Activate emergency response organizations
- Interface with regulatory agencies and the media

#### **Health and Safety Manager:**

- Shall assign and implement personal protective equipment and procedures;
- Shall establish site control per EPA's "Interim Standard Operating Safety Guides, Revised September, 1982"
- Shall assure response compliance with CFR, 1910-120.

#### **Technical Planning:**

- Shall coordinate and assign mobilization of response contractors personnel and equipment
- Shall determine contain and control priorities
- Shall manage responder resources to effectively utilize them

- Shall provide for surveillance to ensure that all response actions are properly performed
- Shall provide the necessary support activities and documents throughout response operations

**Finance Manager:**

- Shall immediately negotiate all costs for response contractor support.
- Shall monitor contractor performance including daily progress reports.
- Verify equipment and labor timekeeping
- Document all costs incurred by contractor(s) during response/cleanup operations.

**Legal Counsel:**

- Shall provide legal advice on regulatory requirement and tort claims
- Shall provide for a thorough investigation of the Incident including documentation of evidence, sampling activities, witness testimony and damages.

**Operations Logistics:**

- Shall thoroughly document all expenditures and receive written notifications and instructions from empowered managers.
- Assure adequate staffing and remediation/cleanup mobilization and support logistics.
- Shall manage field operations.
- Execute work plan and schedule.
- Enforce safety procedures and site control.

The following individuals are assigned to the above responsible positions.

Incident Commander	Sr. EnSafe Representative (Onsite)	Work (901) 372-7962
Alternate Incident Commander	Mr. Phil Coop (EnSafe) Mr. Doug Bailey (Carrier)	Work (901) 372-7962 Home (901) 753-7501 Work (315) 433-4248
Technical Planning Manager	Mr. Craig Wise (EnSafe)	Work (901) 372-7962 Home (901) 372-9618
Health and Safety Manager	Mr. John H. Borowski (EnSafe)	Work (901) 372-7962 Home (901) 527-7672

Finance	Mr. Mike Wood	Work (901) 372-7962 Home (901) 758-0586
Legal Counsel	Mr. Timothy Vandervere Mr. Russ Randle (Patton, Boggs, & Blow)	Work (202) 457-6000 Work (202) 457-6000
Operations/Logistics	Sr. Contractor Representative	N/A

### **11.2 Notifications and Emergency Communications**

In the event of a release of hazardous materials or constituents as a result of the remediation activities at Carrier Collierville, the Senior EnSafe Inc. representative onsite shall assume the responsibilities of Incident Commander. In addition to notifying the members of the incident command team, the following emergency response and regulatory organizations shall be immediately notified.

Collierville Fire Department	(901) 853-3223
Collierville Police Department	(901) 853-3207
CHEMTREC	(800) 682-9211
EPA Region IV (Ms. Beth Brown)	(404) 347-7791
Germantown Community Hospital/Methodist East	(401) 757-6622
Site Command Post	(901) 483-0824

Each of the above organizations will be introduced to the project and shall receive a copy of this Health & Safety Plan and the Contingency Plan. A Response Contractor will be retained and shall have demonstrated experience in emergency incident response and cleanup.

### **11.3 Site Resources**

Telephones for emergency use are located at the command post and the decontamination building. Additionally, portable telephones are available at each work area that is remote from these locations. First aid equipment, including eye wash facilities, is located at the decontamination building. Restrooms and water will be located at the decontamination building. (See Figure 11.1 for locations)

Environmental and Safety Designs, Inc.

**ENSAFE** <sup>SM</sup>

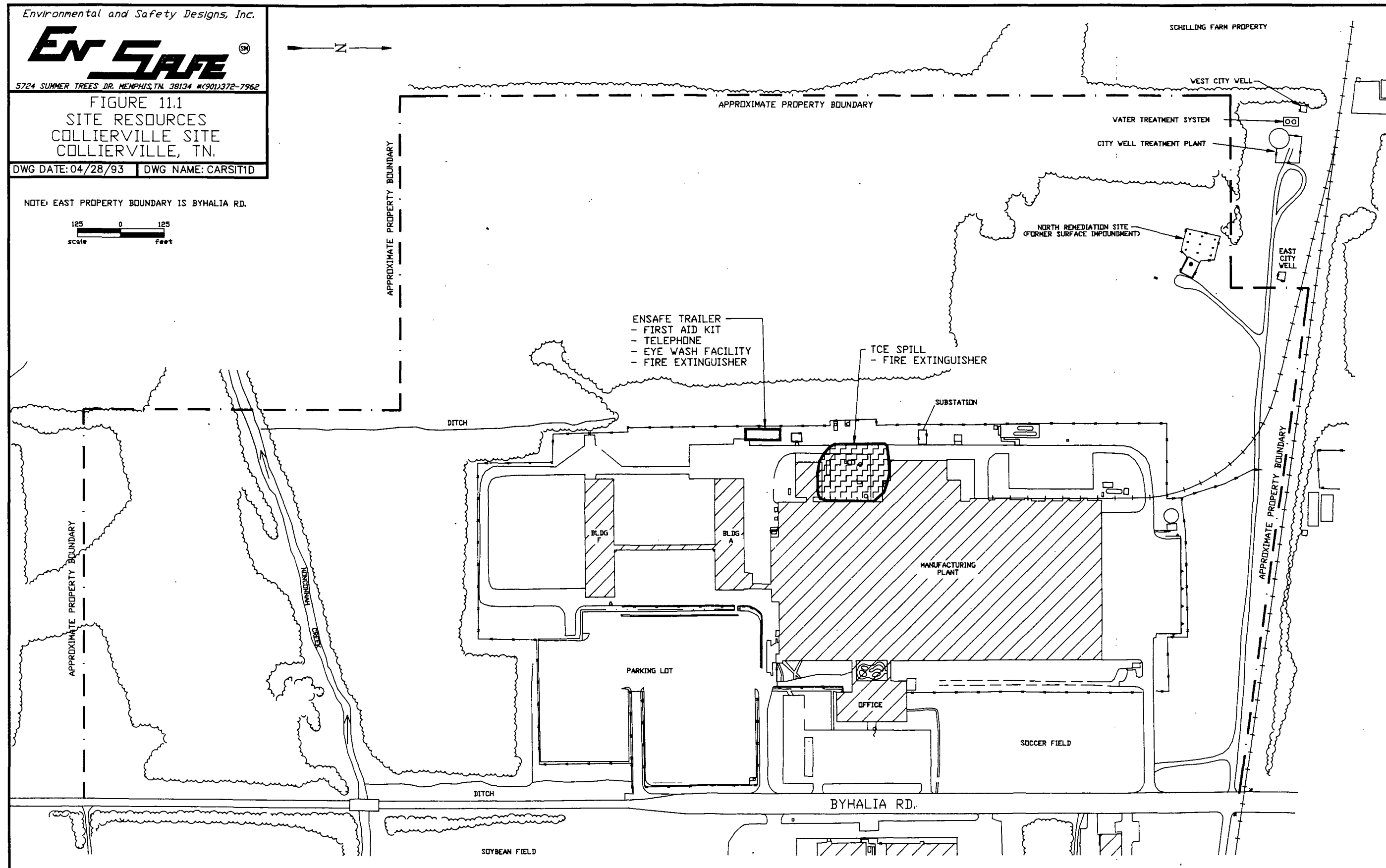
5724 SUMMER TREES DR. MEMPHIS, TN 38134 (901) 372-7962

FIGURE 11.1  
SITE RESOURCES  
COLLIERVILLE SITE  
COLLIERVILLE, TN.

DWG DATE: 04/28/93 DWG NAME: CARST1D

NOTE: EAST PROPERTY BOUNDARY IS BYHALIA RD.

125 0 125  
scale feet



#### 11.4 Personnel Roles and Lines of Authority

The EnSafe Site Manager and the Remediation Contractor have primary responsibility for responding to and correcting emergency situations. This includes taking appropriate measures to ensure the safety of site personnel and the public. Possible actions may involve evacuation of personnel from the site area, and evacuation of adjacent residents. These managers are additionally responsible for ensuring that corrective measures have been implemented, appropriate authorities are notified, and follow up reports completed. The EnSafe Health and Safety Officer may be called upon to act on the behalf of the site supervisors, and will direct responses to any medical emergency. The individual contractor organizations are responsible for assisting the EnSafe Site Manager in the performance of his mission within the parameters of their scope of work.

EnSafe Site Manager	Mr. Craig Wise
EnSafe Site Representative	Mr. Ted Blahnik
EnSafe Health and Safety Officer	Mr. John Borowski, C.I.H.
Alternate Shift Health and Safety Officers are:	Mr. Craig Wise Mr. Ted Blahnik
Personnel with American Red Cross Standard First Aid Training and Adult CPR Training	Mr. Ted Blahnik Mr. John Borowski Mr. Craig Wise

#### 11.5 Fire or Explosion

In the event of a fire or explosion, the local fire department will be summoned immediately. Upon their arrival, the shift supervisor or site manager will advise the fire commander of the location, nature, and identification of the hazardous materials onsite.

If it is safe to do so, site personnel may:

- Use fire fighting equipment available onsite to control or extinguish the fire; and
- Remove or isolate flammable or other hazardous materials which may contribute to the fire.

If it is not safe to take the above actions, the work area must be evacuated.

## **11.6 Spills or Leaks**

In the event of a spill or leak, site personnel will:

- Inform the supervisor immediately;
- Locate the source of the spillage and stop the flow if it can be done safely;
- Begin containment and recovery of the spilled materials.

## **11.7 Emergency Equipment/Facilities**

Figure 11.1 provides a map of the site and identifies the location of the following emergency equipment:

- First Aid Kits
- Telephones
- Eye Wash Stations
- Emergency Showers
- Fire Extinguisher

## CHEMTOX DATA

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## ----- IDENTIFIERS -----

CHEMTOX RECORD 167  
NAME: 1,2-DICHLOROETHYLENE  
SYNONYMS: ACETYLENE DICHLORIDE; 1,2-DICHLOR-AETHEN (German);  
DICHLORO-1,2-ETHYLENE (French); sym-DICHLOROETHYLENE;  
1,2-DICHLOROETHYLENE; DIOFORM; NCI-C56031; CIS-ACETYLENE  
DICHLORIDE; TRANS-ACETYLENE DICHLORIDE;  
SYS-DICHLOROETHYLENE  
CAS: 540-59-0 RTECS: KV9360000  
FORMULA: C2H2Cl2 MOL WT: 96.94  
WLN: G1U1G  
CHEMICAL CLASS: Halogenated h-carbon

See other identifiers listed below under Regulations.

## ----- PROPERTIES -----

PHYSICAL DESCRIPTION: COLORLESS LIQUID WITH AN ETHER-LIKE, SLIGHTLY ACRID  
ODOR, LIKE CHLOROFORM

BOILING POINT:	113 K	-160.2 C	-256.3 F
MELTING POINT:	255.38 K	-17.8 C	0 F
FLASH POINT:	275 K	1.8 C	35.3 F
TO IGNITION:	733.15 K	460 C	860 F
OR PRESSURE:	180 MM		
U L:	12.8 %		
LEL:	9.7 %		
IONIZATION POTENTIAL (eV):	9.65		
VAPOR DENSITY:	3.34 (air=1)		
SPECIFIC GRAVITY:			
DENSITY:	1.28g/mL		
WATER SOLUBILITY:	0.35 TO 0.63%		
INCOMPATIBILITIES:	STRONG OXIDIZERS, NITROGEN DIOXIDE, SOLID CAUSTIC ALKALIES OR THEIR CONCENTRATED SOLUTIONS; DIFLUOROMETHYLENE, DEHYPOFLUORITEI		

REACTIVITY WITH WATER: No data on water reactivity  
REACTIVITY WITH COMMON MATERIALS: GRADUALLY DECOMPOSES BY AIR, LIGHT, AND  
MOISTURE, FORMING HYDROGEN CHLORIDE  
Source: MI  
STABILITY DURING TRANSPORT: No Data  
NEUTRALIZING AGENTS: No data  
POLYMERIZATION POSSIBILITIES: WILL NOT OCCUR UNDER NORMAL SHIPPING  
CONDITIONS. REACTION NOT VIGOROUS.

TOXIC FIRE GASES: None reported other than possible  
unburned vapors  
OR DETECTED AT (ppm): 0.085 PPM  
OR DESCRIPTION: PLEASANT, ETHER-LIKE Source: NYDH



100 % ODOR DETECTION:

No data

----- REGULATIONS -----

DOT hazard class: Not given  
DOT guide: 29  
Identification number: UN1150  
DOT shipping name: DICHLOROETHYLENE  
Packing group:  
Label(s) required:  
Special provisions:  
Packaging exceptions:  
Non bulk packaging:  
Bulk packaging:  
Quantity limitations-  
Passenger air/rail:  
Cargo aircraft only:  
Vessel stowage:  
Other stowage provisions:  
STCC NUMBER: 4909145

CLEAN WATER ACT Sect.307:No  
CLEAN WATER ACT Sect.311:No  
CLEAN AIR ACT: Not listed  
EPA WASTE NUMBER:  
CERCLA REF: Y  
RQ DESIGNATION: Not listed  
SARA TPQ VALUE: Not listed  
SARA Sect. 312  
categories:

Acute toxicity: adverse effect to target organs.  
Reactive hazard: unstable/reactive.

LISTED IN SARA Sect 313: Yes  
de minimus CONCENTRATION: 1.0 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: Flammable liquid - Mailable as ORM-D  
Mailability: Domestic surface mail only  
Max per parcel: 1 QT METAL; 1 PT OTHER

NFPA CODES:

HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with  
self-contained breathing apparatus.  
FLAMMABILITY (RED) : (3) This material can be ignited under almost all  
temperature conditions.  
REACTIVITY (YELLOW): (2) Normally unstable and readily undergoes violent  
change, but does not detonate.  
SPECIAL : Unspecified

----- TOXICITY DATA -----

SHORT TERM TOXICITY: Inhalation: MAY CAUSE DIZZINESS, DROWSINESS, NAUSEA,  
VOMITING, WEAKNESS, TREMORS, CRAMPS, AND AT HIGH

LEVELS UNCONSCIOUSNESS. Skin: MAY CAUSE IRRITATION.  
Eyes: MAY CAUSE IRRITATION. Ingestion: NO REPORTS OF  
HUMAN INGESTION, BUT MAY CONTRIBUTE TO SYMPTOMS LISTED  
UNDER INHALATION. (NYDH)

LONG TERM TOXICITY: MAY CAUSE DIZZINESS, DROWSINESS, NAUSEA, VOMITING,  
WEAKNESS AND INFLAMMATION OF THE LUNGS. THIS  
SUBSTANCE HAS PRODUCED KIDNEY AND LIVER INJURY AT HIGH  
LEVELS IN LABORATORY ANIMALS. WHETHER IT DOES SO IN  
HUMANS IS NOT KNOWN. (NYDH)

TARGET ORGANS: RESP SYS, EYES, CNS  
SYMPTOMS: Inhalation causes nausea, vomiting, weakness, tremor,  
epigastric cramps, central nervous depression. Contact  
with liquid causes irritation of eyes and (on  
prolonged contact) skin. Ingestion causes slight  
depression to deep narcosis. Source: CHRIS

CONC IDLH: 4000PPM

NIOSH REL:

ACGIH TLV: TLV = 200 ppm(790 mg/M3)

ACGIH STEL: 250 ppm

OSHA PEL: Transitional Limits:  
PEL = 200 ppm(790mg/M3)  
Final Rule Limits:  
TWA = 200 ppm (790 mg/M3)

INFORMATION: 200 ppm  
790 mg/M3  
Substance with systemic effects, onset of effect less  
than or equal to 2 hrs: Peak = 2xMAK for 30 minutes, 4  
times per shift of 8 hours.  
Danger of cutaneous absorption  
Carcinogenic working material without MAK

CARCINOGEN?: STATUS:

CARCINOGEN LISTS:

IARC: Not listed  
MAK: Not listed  
NIOSH: Not listed  
NTP: Not listed  
ACGIH: Not listed  
OSHA: Not listed

LD50 value: orl-rat LD50:770 mg/ kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1991)

orl-rat LD50:770 mg/kg  
ipr-mus LD50:2 gm/kg  
ihl-frg LCLO:117 mg/m3/1H

productive toxicity (1991 RTECS):

This chemical has no known mammalian reproductive toxicity.

PRODUCTIVE TOXICITY DATA (1991 RTECS)

----- PROTECTION AND FIRST AID -----

PROTECTION SUGGESTED

FROM THE CHRIS MANUAL:

RUBBER GLOVES; SAFETY GOGGLES; AIR SUPPLY MASK OR SELF-CONTAINED BREATHING APPARATUS.

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

\*\* WEAR APPROPRIATE EQUIPMENT TO PREVENT:

Repeated or prolonged skin contact.

\*\* WEAR EYE PROTECTION TO PREVENT:

Reasonable probability of eye contact.

\*\* EXPOSED PERSONNEL SHOULD WASH:

Promptly when skin becomes wet.

\*\* REMOVE CLOTHING:

Immediately remove any clothing that becomes wet to avoid any flammability

\*\* REFERENCE: NIOSH

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114)

IA (1,2-DICHLOROETHYLENE)

1000 ppm: Any powered air-purifying respirator with organic vapor cartridge(s). \* Substance causes eye irritation or damage; eye protection needed. / Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s).

4000 ppm: Any supplied-air respirator operated in a continuous flow mode. \* Substance causes eye irritation or damage; eye protection needed. / Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. / Any self-contained breathing apparatus with a full facepiece. / Any supplied-air respirator with a full facepiece.

EMERGENCY OR PLANNED ENTRY IN UNKNOWN CONCENTRATIONS OR IDLH CONDITIONS.:

Any self-contained breathing apparatus with full facepiece and operated in a pressure-demand or other positive pressure mode. / Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

ESCAPE: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. / Any appropriate escape-type self-contained breathing apparatus.

----- INITIAL INCIDENT RESPONSE -----

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.5 (1990).

7 SHIPPING NAME: DICHLOROETHYLENE

1 ID NUMBER: UN1150

## \* POTENTIAL HAZARDS \*

## FIRE OR EXPLOSION

Flammable/combustible material; may be ignited by heat, sparks or flames.

Vapors may travel to a source of ignition and flash back.

Container may explode in heat of fire.

Vapor explosion hazard indoors, outdoors or in sewers.

Runoff to sewer may create fire or explosion hazard.

## \*HEALTH HAZARDS

May be poisonous if inhaled.

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

## \* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire.

CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities.

## \*FIRE

Some of these materials may react violently with water.

Small Fires: Dry chemical, CO<sub>2</sub>, water spray or regular foam.

Large Fires: Water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Do not get water inside container.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Withdraw immediately in case of rising sound from venting safety device or or any discoloration of tank due to fire.

## \*SPILL OR LEAK

Shut off ignition sources; no flares, smoking or flames in hazard area.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Use water spray to reduce vapor; do not get water inside container.

Small Spills: Take up with sand, or other noncombustible absorbent material and place into containers for later disposal.

Large Spills: Dike far ahead of spill for later disposal.

## \*FIRST AID

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement. The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms.

## CHEMTOX DATA

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## IDENTIFIERS

CHEMTOX RECORD 166 LAST UPDATE OF THIS RECORD: 12/03/91  
NAME: 1,1-DICHLOROETHYLENE  
SYNONYMS: CHLORURE DE VINYLIDENE (French); 1,1-DCE;  
1,1-DICHLOROETHENE (9CI); 1,1-DICHLOROETHYLENE; ETHENE,  
1,1-DICHLORO-; NCI-C54262; SCONATEX; VDC; VINYLIDENE  
CHLORIDE (II); VINYLIDENE DICHLORIDE; VINYLIDINE CHLORIDE;  
asym-DICHLOROETHYLENE  
CAS: 75-35-4 RTECS: KV9275000  
FORMULA: C2H2Cl2 MOL WT: 96.94  
WLN: GYGU1  
CHEMICAL CLASS: Olefin; Halogenated h-carbon

See other identifiers listed below under Regulations.

## PROPERTIES

PHYSICAL DESCRIPTION: COLORLESS, VOLATILE, WATERY LIQUID WITH A SWEET ODOR  
RESEMBLING THAT OF CHLOROFORM

BOILING POINT:	310 K	36.8 C	98.3 F
MELTING POINT:	151 K	-122.2 C	-187.9 F
FLASH POINT:	255.37 K	-17.8 C	-.1 F
WTO IGNITION:	808 K	534.8 C	994.7 F
VAPOR PRESSURE:	50.95mm @ -28.36		
LEL:	16 %		
LEL:	7.3 %		
VAPOR DENSITY:	3.3 (air=1)		
SPECIFIC GRAVITY:	1.21 20C		
DENSITY:	1.21 g/mL @ 20 C		
WATER SOLUBILITY:	PRACTICALLY INSOLUBLE		
INCOMPATIBILITIES:	STRONG OXIDIZERS, AIR, CHLOROTRI-FLUOROETHYLENE; OZONE; PERCHLORYL FLUORIDE		

REACTIVITY WITH WATER: No data on water reactivity  
REACTIVITY WITH COMMON MATERIALS: COPPER AND ALUMINUM CAN CAUSE  
POLYMERIZATION.  
STABILITY DURING TRANSPORT: No Data  
NEUTRALIZING AGENTS: No data  
POLYMERIZATION POSSIBILITIES: CAN OCCUR IF EXPOSED TO SUNLIGHT, AIR,  
COPPER, ALUMINUM, HEAT.  
TOXIC FIRE GASES: HCL\CORROSIVE  
ODOR DETECTED AT (ppm): Unknown  
ODOR DESCRIPTION: SWEET; LIKE CARBON TETRACHLORIDE OR  
CHLOROFORM Source:CHRIS  
100 % ODOR DETECTION: No data

## REGULATIONS

DOT hazard class: 3 FLAMMABLE LIQUID  
DOT guide: 26  
Identification number: UN1303  
Shipping name: Vinylidene chloride, inhibited  
Packing group: I  
Label(s) required: FLAMMABLE LIQUID  
Special provisions: T23,T29  
Packaging exceptions: 150  
Non bulk packaging: 201  
Bulk packaging: 243  
Quantity limitations-  
Passenger air/rail: 1 L  
Cargo aircraft only: 30 L  
Vessel stowage: E  
Other stowage provisions: 40,M2  
STCC NUMBER:

CLEAN WATER ACT Sect.307:Yes

CLEAN WATER ACT Sect.311:No

National Primary Drinking Water Regulations

Maximum Contaminant Levels (MCL): 0.007 mg/mL (01/09/89)

Maximum Contaminant Level Goals (MCLG): 0.007 mg/mL (01/09/89)

CLEAN AIR ACT: CAA '90 Listed

EPA WASTE NUMBER: U078,D029

CERCLA REF: Y

RQ DESIGNATION: B 100 pounds (45.4 kg) CERCLA

SARA TPQ VALUE: Not listed

SARA Sect. 312  
categories:

Acute toxicity: adverse effect to target organs.

Chronic toxicity: carcinogen

Reactive hazard: unstable/reactive.

LISTED IN SARA Sect 313: Yes

de minimus CONCENTRATION: 1.0 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: Flammable liquid - Mailable as ORM-D

Mailability: Domestic surface mail only

Max per parcel: 1 QT METAL; 1 PT OTHER

NFPA CODES:

HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with self-contained breathing apparatus.

FLAMMABILITY (RED) : (4) This material forms readily ignitable mixtures in air.

REACTIVITY (YELLOW): (2) Normally unstable and readily undergoes violent change, but does not detonate.

SPECIAL : Unspecified

----- TOXICITY DATA -----

SHORT TERM TOXICITY: Unknown

LONG TERM TOXICITY: POSSIBLE RISKS OF LONG TERM EFFECTS. \*\* Source: HCL3

TARGET ORGANS: RESP SYS, EYES, CNS  
SYMPTOMS: Vapor can cause dizziness and drunkenness; high levels cause anesthesia. Liquid irritates eyes and skin.  
Source: CHRIS

CONC IDLH: Unknown

NIOSH REL: Potential occupational carcinogen (Limit of quantitation 0.4) (use 1910.1017) VINYL CHLORIDE

ACGIH TLV: TLV = 5 ppm  
ACGIH STEL: 20 ppm

OSHA PEL: Final Rule Limits:  
TWA = 1 ppm (4 mg/M3)

MAK INFORMATION: 2 ppm  
8 mg/M3  
Substance with systemic effects, onset of effect less than or equal to 2 hrs: Peak = 2xMAK for 30 minutes, 4 times per shift of 8 hours.  
There is no reason to fear a risk of damage to the developing embryo or fetus when MAK values are adhered to.  
A compound which is justifiably suspected of having carcinogenic potential.

RCINOGEN?: Y STATUS: ANIMAL POSITIVE  
ERENCES:  
ANIMAL POSITIVE IARC\*\* 19,439,79  
HUMAN INDEFINITE IARC\*\* 19,439,79

CARCINOGEN LISTS:  
IARC: Not classified as to human carcinogenicity or probably not carcinogenic to humans.  
MAK: A compound which is justifiably suspected of having carcinogenic potential.  
NIOSH: Carcinogen defined by NIOSH with no further categorization.  
NTP: Not listed  
ACGIH: Not listed  
OSHA: Not listed

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)  
ihl-hmn TCLo:25 ppm CHINAG (11),463,76  
BEHAVIORAL  
General anesthetic  
LIVER  
Other changes  
KIDNEY, URETER, BLADDER  
Other changes

LD50 value: orl-rat LD50:200 mg/ kg



OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1991)

orl-rat LD50:200 mg/kg  
ihl-rat LC50:6350 ppm/4H  
orl-mus LD50:194 mg/kg  
orl-dog LDLo:5750 mg/kg  
ivn-dog LDLo:225 mg/kg  
scu-rbt LDLo:3700 mg/kg

Reproductive toxicity (1991 RTECS):

This chemical is a mammalian reproductive toxin.

REPRODUCTIVE TOXICITY DATA (1991 RTECS)

orl-rat TDLo:200 mg/kg (6-15D preg) TXAPA9 49,189,79  
EFFECTS ON FERTILITY  
Other measures of fertility  
EFFECTS ON EMBRYO OR FETUS  
Fetotoxicity(except death,e.g.,stunted fetus)

ihl-rat TCLo:80 ppm/7H (6-15D preg) TXAPA9 49,189,79  
SPECIFIC DEVELOPMENTAL ABNORMALITIES  
Musculoskeletal system

ihl-rat TCLo:55 ppm/6H (55D pre) JTEHD6 3,965,77  
EFFECTS ON FERTILITY  
Female fertility index

----- PROTECTION AND FIRST AID -----  
PROTECTION SUGGESTED  
FROM THE CHRIS MANUAL:

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

- \*\* WEAR APPROPRIATE EQUIPMENT TO PREVENT:  
Repeated or prolonged skin contact.
- \*\* WEAR EYE PROTECTION TO PREVENT:  
Reasonable probability of eye contact.
- \*\* EXPOSED PERSONNEL SHOULD WASH:  
Promptly when skin becomes wet.
- \*\* REMOVE CLOTHING:  
Immediately remove any clothing that becomes wet to avoid any flammability
- \*\* REFERENCE: NIOSH

FIRST AID (NIOSH):

EYE:  
IRR IMMED  
N:  
SOAP WASH PROMPTLY

INHALATION:  
ART RESP  
INGESTION:  
IPECAC, VOMIT

----- INITIAL INCIDENT RESPONSE -----

US Department of Transportation Guide to Hazardous Materials Transport  
Information - Publication DOT 5800.5 (1990).

DOT SHIPPING NAME: Vinylidene chloride, inhibited

DOT ID NUMBER: UN1303

ERG90

GUIDE 26

\* POTENTIAL HAZARDS \*

\*FIRE OR EXPLOSION

Flammable/combustible material; may be ignited by heat, sparks or flames.

Vapors may travel to a source of ignition and flash back.

Container may explode in heat of fire.

Vapor explosion hazard indoors, outdoors or in sewers.

Runoff to sewer may create fire or explosion hazard.

\*HEALTH HAZARDS

May be poisonous if inhaled or absorbed through skin.

Vapors may cause dizziness or suffocation.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

\* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire.

CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities.

\*FIRE

Small Fires: Dry chemical, CO2 or Halon, water spray or alcohol-resistant foam.

Large Fires: Water spray, fog or alcohol-resistant foam.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

\*SPILL OR LEAK

Shut off ignition sources; no flares, smoking or flames in hazard area.

Stop leak if you can do it without risk.

Water spray may reduce vapors; but it may not prevent ignition in closed spaces.

Small Spills: Take up with sand or other noncombustible absorbent

material and place into containers for later disposal.

Large Spills: Dike far ahead of liquid spill for later disposal.

#### FIRST AID

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.

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## CHEMTOX DATA

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## ----- IDENTIFIERS -----

CHEMTOX RECORD 5249 LAST UPDATE OF THIS RECORD: 12/03/91  
NAME: ETHYLENE, TETRACHLORO-  
SYNONYMS: ANKILOSTIN; ANTISOL 1; CARBON BICHLORIDE; CARBON  
DICHLORIDE; CZTEROCHLOROETYLEN (Polish); DIDAKENE;  
DOW-PER; ENT 1,860; ETHENE, TETRACHLORO-; ETHYLENE  
TETRACHLORIDE; FEDAL-UN; NCI-C04580; NEMA; PER; PERAWIN;  
PERC; PERCHLOORETHYLEEN, PER (Dutch); PERCHLOR;  
PERCHLORAETHYLEN, PER (German); PERCHLORETHYLENE;  
PERCHLORETHYLENE, PER (French); PERCHLOROETHYLENE;  
PERCLEN; PERCLOROETILENE (Italian); PERCOSOLVE; PERK;  
PERKLONE; PERSEC; TETLEN; TETRACAP; TETRACHLOORETHEEN  
(Dutch); TETRACHLORAETHEN (German); TETRACHLORETHYLENE;  
TETRACHLOROETHENE; TETRACHLOROETHYLENE;  
1,1,2,2,-TETRACHLOROETHYLENE; TETRACHLOROETHYLENE (DOT);  
TETRACLOROETENE (Italian); TETRALENO; TETRALEX; TETRAVEC;  
TETROGUER; TETROPIL  
CAS: 127-18-4 RTECS: KX3850000  
FORMULA: C2Cl4 MOL WT: 165.82  
WLN: GYGUYGG  
CHEMICAL CLASS: FT

See other identifiers listed below under Regulations.

## ----- PROPERTIES -----

PHYSICAL DESCRIPTION: COLORLESS LIQUID, CHLOROFORM-LIKE ODOR.  
BOILING POINT: 394.2 K 121 C 249.8 F  
MELTING POINT: 249.65 K -23.5 C -10.3 F  
FLASH POINT: NA  
AUTO IGNITION: NA  
VAPOR PRESSURE: 15.8MM @ 22C  
UEL: NA  
LEL: NA  
IONIZATION POTENTIAL (eV): 9.32  
VAPOR DENSITY: No data  
SPECIFIC GRAVITY: 1.625 @20/4C  
DENSITY: 1.6311 @ 15/4C  
WATER SOLUBILITY: QUITE SOLUBLE IN H2O(0.015G/ML @20C), IT IS M  
INCOMPATIBILITIES: STRONG OXIDIZERS, CHEMICALLY ACTIVE  
METALS, SUCH AS BARIUM, LITHIUM,  
BERYLLIUM, SODIUM  
REACTIVITY WITH WATER: No data on water reactivity  
REACTIVITY WITH COMMON MATERIALS: No data  
STABILITY DURING TRANSPORT: No Data  
NEUTRALIZING AGENTS: No data  
POLYMERIZATION POSSIBILITIES: No data  
AIC FIRE GASES: HCL AND PHOSGENE\CORROSIVE

ODOR DETECTED AT (ppm): 5 ppm  
ODOR DESCRIPTION: mildly sweet Source:CHRIS  
% ODOR DETECTION: No data

----- REGULATIONS -----

DOT hazard class: 6.1 POISON  
DOT guide: 74  
Identification number: UN1897  
DOT shipping name: Tetrachloroethylene  
Packing group: III  
Label(s) required: KEEP AWAY FROM FOOD  
Special provisions: N36  
Packaging exceptions: 153  
Non bulk packaging: 203  
Bulk packaging: 241  
Quantity limitations-  
Passenger air/rail: 60 L  
Cargo aircraft only: 220 L  
Vessel stowage: A  
Other stowage provisions: 40, M2  
STCC NUMBER: 4940355

CLEAN WATER ACT Sect.307:Yes

CLEAN WATER ACT Sect.311:No

National Primary Drinking Water Regulations

Maximum Contaminant Levels (MCL): 0.005 mg/mL (07/30/92)

Maximum Contaminant Level Goals (MCLG): 0 mg/mL (07/30/92)

CAN AIR ACT: CAA '90 Listed

SA WASTE NUMBER: U210, D039

CERCLA REF: Y

RQ DESIGNATION: B 100 pounds (45.4 kg) CERCLA

SARA TPQ VALUE: Not listed

SARA Sect. 312

categories:

Acute toxicity: adverse effect to target organs.

Chronic toxicity: carcinogen

Chronic toxicity: adverse effect to target organ  
after long period of exposure.

LISTED IN SARA Sect 313: Yes

de minimus CONCENTRATION: 0.1 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: ORM-A

Mailability: Domestic service and air transportation; shipper's declaratic

Max per parcel: 10 GAL; 1 PT

NFPA CODES:

HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with  
self-contained breathing apparatus.

FLAMMABILITY (RED) : (0) This material does not readily burn.

REACTIVITY (YELLOW): (0) Stable even under fire conditions.

SPECIAL : Unspecified

----- TOXICITY DATA -----

SHORT TERM TOXICITY: Inhalation: EXPOSURES OF 200 PPM FOR 1 HOUR CAN CAUSE IRRITATION OF THE NOSE, MOUTH AND THROAT, DIZZINESS, HEADACHES AND LIGHTEADEDNESS; EXPOSURES OF 1,000 PPM FOR 30 MINUTES CAN CAUSE DIFFICULT BREATHING, WEAKNESS, LOSS OF MUSCLE CONTROL, IRRITABILITY, TREMORS, CONVULSIONS, PARALYSIS, COMA, HEART IRREGULARITIES AND DEATH. Skin: CAN CAUSE DRY, SCALY SKIN, A MILD TO MODERATE BURNING SENSATION, REDNESS AND INFLAMMATION. Eyes: CAN CAUSE BURNING AND IRRITATION. Ingestion: CAN CAUSE NAUSEA, VOMITING, DIARRHEA, BLOODY STOOL, A REDDENING OF FACE AND NECK, WEAKNESS AND LOSS OF MUSCLE CONTROL. (NYDH)

LONG TERM TOXICITY: EXPOSURES OVER 200 PPM DURING WEEKS OR MONTHS CAN CAUSE IRRITATION OF THE RESPIRATORY TRACT, NAUSEA, HEADACHE, SLEEPLESSNESS, ABDOMINAL PAINS, CONSTIPATION, DIZZINESS, INCREASED PERSPIRATION, FATIGUE, SKIN INFECTION, KIDNEY AND LIVER DAMAGE, FLUID IN THE LUNGS AND COMA. MOST OF THESE EFFECTS WILL DISAPPEAR AFTER EXPOSURE IS STOPPED. TETRACHLOROETHYLENE AT HIGH LEVELS HAS CAUSED CANCER AND BIRTH DEFECTS IN MICE. WHETHER IT CAUSES CANCER IN HUMANS IS UNKNOWN. (NYDH)

TARGET ORGANS: SKIN, MUCOUS MEMBRANE, EYES, CNS, GASTROINTESTINAL TRACT. LI  
SYMPTOMS: Vapor can affect central nervous system and cause anesthesia. Liquid may irritate skin after prolonged contact. May irritate eyes but causes no injury.  
Source: CHRIS

CONC IDLH: 500ppm

NIOSH REL: Potential occupational carcinogen --MINIMIZE EXPOSURE  
(Limit of quantitation 0.4 ppm)

ACGIH TLV: TLV = 50 ppm

ACGIH STEL: 200 ppm

OSHA PEL: Transitional Limits:  
PEL = 100 PPM; CEILING = 200 PPM; MAXIMUM PEAK ABOVE CEILING  
Final Rule Limits:  
TWA = 25 ppm (170 mg/M3)

MAK INFORMATION: 50 ppm  
345 mg/M3  
Substance with systemic effects, onset of effect less than or equal to 2 hrs: Peak = 2xMAK for 30 minutes, 4 times per shift of 8 hours.  
There is no reason to fear a risk of damage to the developing embryo or fetus when MAK values are adhered to.  
A compound which is justifiably suspected of having carcinogenic potential.

CARCINOGEN?: N STATUS: INADEQUATE EVIDENCE FOR HUMAN  
CARCINOGEN.

CARCINOGEN LISTS:

IARC: Carcinogen defined by IARC  
to be probably carcinogenic to  
humans, but having (usually) no  
human evidence.  
MAK: A compound which is  
justifiably suspected of having  
carcinogenic potential.  
NIOSH: Carcinogen defined by NIOSH  
with no further categorization.  
NTP: Carcinogen defined by NTP as  
reasonably anticipated to be  
carcinogenic, with limited  
evidence in humans or sufficient  
evidence in experimental animals.  
ACGIH: Not listed  
OSHA: Not listed

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)

ihl-hmn TCLo:96 ppm/7H NTIS\*\* PB257-185  
PERIPHERAL NERVE AND SENSATION  
Local anesthetic  
SENSE ORGANS  
Eye  
Conjunctive irritation  
BEHAVIORAL  
Hallucinations, distorted perceptions  
  
ihl-man TCLo:280 ppm/2H AMIHBC 5,566,52  
SENSE ORGANS  
Eye  
Conjunctive irritation  
BEHAVIORAL  
General anesthetic

LD50 value: orl-rat LD50:2629 mg/ kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1991)

orl-rat LD50:2629 mg/kg  
ihl-rat LC50:34200 mg/m3/8H  
ipr-rat LD50:4678 mg/kg  
orl-mus LD50:8100 mg/kg  
ihl-mus LC50:5200 ppm/4H  
scu-mus LD50:65 gm/kg  
orl-dog LDLo:4000 mg/kg  
ipr-dog LD50:2100 mg/kg  
ivn-dog LDLo:85 mg/kg  
orl-cat LDLo:4000 mg/kg  
orl-rbt LDLo:5000 mg/kg  
scu-rbt LDLo:2200 mg/kg

IRRITATION DATA: (Source: NIOSH RTECS 1991)

skn-rbt 810 mg/24H SEV  
eye-rbt 162 mg MLD

Reproductive toxicity (1991 RTECS):

This chemical is a mammalian reproductive toxin.

REPRODUCTIVE TOXICITY DATA (1991 RTECS)

ihl-rat TCLo:1000 ppm/24H (14D pre/1-22D preg) APTOD9  
19,A21,80

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Musculoskeletal system

ihl-rat TCLo:1000 ppm/24H (1-22D preg) APTOD9 19,A21,80

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

ihl-rat TCLo:900 ppm/7H (7-13D preg) TJADAB 19,41A,79

EFFECTS ON NEWBORN

Live birth index(# fetuses per liter)

EFFECTS ON NEWBORN

EFFECTS ON NEWBORN

Behavioral

ihl-rat TCLo:300 ppm/7H (6-15D preg) TXAPA9 32,84,75

EFFECTS ON FERTILITY

Post-implantation mortality

ihl-mus TCLo:300 ppm/7H (6-15D preg) TXAPA9 32,84,75

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Musculoskeletal system

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Homeostatis

NO SIGNIFICANT

RISK LEVEL(Ca P65): 14 micrograms/day

----- PROTECTION AND FIRST AID -----  
PROTECTION SUGGESTED  
FROM THE CHRIS MANUAL:

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS

\*\* WEAR APPROPRIATE EQUIPMENT TO PREVENT:

Repeated or prolonged skin contact.

\*\* WEAR EYE PROTECTION TO PREVENT:

Reasonable probability of eye contact.

EXPOSED PERSONNEL SHOULD WASH:

Promptly when skin becomes contaminated.



REMOVE CLOTHING:

Promptly remove non-impervious clothing that becomes contaminated.

\*\* REFERENCE: NIOSH

FIRST AID (NIOSH):

EYE:

IRR IMMED

SKIN:

SOAP WASH PROMPTLY

INHALATION:

ART RESP

INGESTION:

IPECAC, VOMIT

----- INITIAL INCIDENT RESPONSE -----

US Department of Transportation Guide to Hazardous Materials Transport  
Information - Publication DOT 5800.5 (1990).

DOT SHIPPING NAME: Tetrachloroethylene

DOT ID NUMBER: UN1897

ERG90

GUIDE 74

\* POTENTIAL HAZARDS \*

HEALTH HAZARDS

Vapors may cause dizziness or suffocation.

Exposure in an enclosed area may be very harmful.

Contact may irritate or burn skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

\*FIRE OR EXPLOSION

Some of these materials may burn, but none of them ignites readily.

Most vapors heavier than air.

Air/vapor mixtures may explode when ignited.

Container may explode in heat of fire.

\* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.  
Stay upwind, out of low areas, and ventilate closed spaces before  
entering.

Positive pressure self-contained breathing apparatus (SCBA) and structural  
firefighters' protective clothing will provide limited protection.

Isolate 1/2 mile in all directions if tank, rail car or tank truck is  
involved in fire.

Remove and isolate contaminated clothing at the site.

CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE.

If water pollution occurs, notify the appropriate authorities.

\*FIRE

Small Fires: Dry chemical or CO2.

Large Fires: Water spray, fog or regular foam.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

**PILL OR LEAK**

Shut off ignition sources; no flares, smoking or flames in hazard area. Stop leak if you can do it without risk.

Small Liquid Spills: Take up with sand, earth or other noncombustible absorbent material.

Large Spills: Dike far ahead of liquid spill for later disposal.

**\*FIRST AID**

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

Use first aid treatment according to the nature of the injury.

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## ----- IDENTIFIERS -----

CHEMTOX RECORD 419

LAST UPDATE OF THIS RECORD: 12/03/91

NAME: VINYL CHLORIDE  
SYNONYMS: CHLOROETHYLENE; VINYL CHLOROIDE; CHLOROETHEN;  
CHLOROETHYLENE; CHLORURE DE VINYLE (FRENCH); CHLORO DI  
VINYLE (ITALIAN); ETHYLENE MONOCHLORIDE; MONOCHLOROETHENE;  
MONOCHLOROETHYLENE (DOT); VINYL CHLORIDE MONOMER; VINYL C  
MONOMER; WINYLU CHLORED (POLISH); VCM; VCL  
CAS: 75-01-4 RTECS: KU9625000  
FORMULA: C2H3Cl MOL WT: 62.50  
WLN: GIU1  
CHEMICAL CLASS: Vinyl halide

See other identifiers listed below under Regulations.

## ----- PROPERTIES -----

PHYSICAL DESCRIPTION: colorless liquified compressed sag with a sweet odor

BOILING POINT:	259.4 K	-13.8 C	7.2 F
MELTING POINT:	-119.4 K	-119.4	-119.4
FLASH POINT:	194 K	-79.2 C	-110.5 F
AUTO IGNITION:	745 K	471.8 C	881.3 F
CRITICAL TEMP:	431.6 Kelvin	158.45 C	317.21 F
CRITICAL PRESS:	5.34 kN/M2	52.6 atm	773 psia
HEAT OF VAP:	160 Btu/lb	88.85 cal/g	3.718x E5 J/kg
HEAT OF COMB:	-8136 Btu/lb	-4523 cal/g	-189x E5 J/kg
VAPOR PRESSURE:	2600 mm @ 25		
UEL:	33 %		
LEL:	3.6 %		
IONIZATION POTENTIAL (eV):	7.57		
VAPOR DENSITY:	2.2 (air=1) (air=1)		
SPECIFIC GRAVITY:	0.969 @ -13C		
DENSITY:	0.969 g/cc or 9.0117 lb/gal		
WATER SOLUBILITY:	insol		
INCOMPATIBILITIES:			

REACTIVITY WITH WATER: No data on water reactivity  
REACTIVITY WITH COMMON MATERIALS: No data  
STABILITY DURING TRANSPORT: No Data  
NEUTRALIZING AGENTS: No data  
POLYMERIZATION POSSIBILITIES: POLYMERIZES IN PRESENCE OF AIR,  
SUNLIGHT, OR HEAT UNLESS STABILIZED BY  
INHIBITORS.

TOXIC FIRE GASES: HCl and unburned toxic vapors  
ODOR DETECTED AT (ppm): 260 ppm  
ODOR DESCRIPTION: Pleasant, sweet Source: CHRIS  
100 % ODOR DETECTION: No data

## ----- REGULATIONS -----

DOT hazard class: 2.1 FLAMMABLE GAS  
T guide: 17  
Identification number: UN1086  
DOT shipping name: Vinyl chloride, inhibited  
Packing group:  
Label(s) required: FLAMMABLE GAS  
Special provisions: B44  
Packaging exceptions: 306  
Non bulk packaging: 304  
Bulk packaging: 314, 315  
Quantity limitations-  
Passenger air/rail: Forbidden  
Cargo aircraft only: 150 kg  
Vessel stowage: B  
Other stowage provisions: 40  
STCC NUMBER: 4905792

CLEAN WATER ACT Sect.307:Yes

CLEAN WATER ACT Sect.311:No

National Primary Drinking Water Regulations

Maximum Contaminant Levels (MCL): 0.002 mg/mL (01/09/89)

Maximum Contaminant Level Goals (MCLG): 0 mg/mL (01/09/89)

CLEAN AIR ACT: CAA '90 Listed

EPA WASTE NUMBER: U043,D043

CERCLA REF:

RQ DESIGNATION: X 1 pound (0.454 kg) CERCLA

RA TPQ VALUE: Not listed

RA Sect. 312

categories:

Acute toxicity: adverse effect to target organs.

Chronic toxicity: carcinogen

Chronic toxicity: adverse effect to target organ  
after long period of exposure.

Fire hazard: flammable.

Sudden pressure: compressed gases.

Reactive hazard: unstable/reactive.

LISTED IN SARA Sect 313: Yes

de minimus CONCENTRATION: 0.1 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: Not given

Mailability: Nonmailable

Max per parcel: 0

NFPA CODES:

HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with  
self-contained breathing apparatus.

FLAMMABILITY (RED) : (4) This material forms readily ignitable mixtures  
in air.

REACTIVITY (YELLOW): (1) Normally stable, but may become unstable at  
elevated temperature and pressures.

SPECIAL : Unspecified

----- TOXICITY DATA -----

SHORT TERM TOXICITY: Inhalation: EXPOSURE AT 8,000 PPM FOR 5 MINUTES CAN CAUSE A FEELING OF INTOXICATION, TIREDNESS, DROWSINESS, ABDOMINAL PAIN, NUMBNESS AND TINGLING IN FINGERS AND TOES, PAINS IN JOINTS, COUGHING, SNEEZING, IRRITABILITY AND LOSS OF APPETITE AND WEIGHT. Skin: CONTACT WITH LIQUID MAY CAUSE FROSTBITE; CONTACT WITH VAPOR MAY CAUSE IRRITATION AND RASH. ABSORPTION IS POSSIBLE THROUGH THE SKIN. Eyes: CAN CAUSE SEVERE AND IMMEDIATE IRRITATION. Ingestion: NONE FOUND. (NYDH)

LONG TERM TOXICITY: MAY CAUSE CLUB-LIKE SWELLING AND SHORTENING OF FINGER TIPS. SKIN MAY BECOME THICKENED AND STIFF WITH COARSE, WHITISH PATCHES. BONES AND JOINTS OF ARMS AND LEGS MAY SUFFER DAMAGE. LIVER AND SPLEEN DAMAGE MAY OCCUR. NOT ALL SYMPTOMS DISAPPEAR AFTER EXPOSURE STOPS. VINYL CHLORIDE HAS CAUSED LIVER CANCER IN OCCUPATIONALLY EXPOSED INDIVIDUALS. (NYDH)

TARGET ORGANS: SKIN, EYES, MUCOUS MEMBRANES, NERVOUS SYSTEM, LIVER, KIDNEYS  
SYMPTOMS: INHALATION: high concentrations cause dizziness, anesthesia, lung irritation. SKIN: may cause frostbite; phenol inhibitor may be absorbed through skin if large amounts of liquid evaporate. Source: CHRIS

CONC IDLH: Unknown

OSHA REL: Potential occupational carcinogen (use 1910.1017)

ACGIH TLV: TLV = 5 ppm Confirmed human carcinogen (A1)  
ACGIH STEL: Not specified

OSHA PEL: Final Rule Limits:  
TWA = 1 ppm  
CEILING = 5 ppm  
CONSULT 29CFR 1910.1017

MAK INFORMATION: Carcinogenic working material without MAK  
Capable of inducing malignant tumors as shown by experience with humans.

CARCINOGEN?: Y STATUS: HUMAN POSITIVE

REFERENCES: HUMAN POSITIVE IARC\*\* 19,377,79  
ANIMAL POSITIVE IARC\*\* 7,291,74  
HUMAN SUSPECTED IARC\*\* 7,291,74  
ANIMAL POSITIVE IARC\*\* 19,377,79  
HUMAN POSITIVE IARC\*\* 28,151,82

CARCINOGEN LISTS: IARC: Carcinogen as defined by  
IARC as carcinogenic to humans,  
with sufficient epidemiological  
evidence.  
MAK: Capable of inducing malignant

tumors as shown by experience in humans.

NIOSH: Carcinogen defined by NIOSH with no further categorization.

NTP: Carcinogen defined by NTP as known to be carcinogenic, with evidence from human studies.

ACGIH: Carcinogen defined by ACGIH TLV Committee as a confirmed human carcinogen, recognized to have carcinogenic or cocarcinogenic potential.

OSHA: Cancer suspect

LD50 value: orl-rat LD50:500 mg/ kg

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1991)

orl-rat LD50:500 mg/kg  
ihl-rat LC50:18 pph/15M  
ihl-mam LCLo:200 ppm/18M

Reproductive toxicity (1991 RTECS):

This chemical is a mammalian reproductive toxin.

REPRODUCTIVE TOXICITY DATA (1991 RTECS)

ihl-man TCLo:30 mg/m3 (5Y male) GTPZAB 24(5),28,80

PATERNAL EFFECTS  
Spermatogenesis

ihl-rat TCLo:100 ppm/6H (26W male) EESADV 10,281,85

PATERNAL EFFECTS  
Testes,epididymis,sperm duct

ihl-rat TCLo:500 ppm/7H (6-15D preg) TXAPA9 33,134,75

EFFECTS ON EMBRYO OR FETUS  
Fetotoxicity(except death,e.g.,stunted fetus)

ihl-rat TCLo:1500 ppm/24H (1-9D preg) TXCYAC 11,45,78

EFFECTS ON FERTILITY  
Post-implantation mortality

ihl-rat TCLo:500 ppm/7H (6-15D preg) EVHPAZ 41,171,81

EFFECTS ON EMBRYO OR FETUS  
Fetotoxicity(except death,e.g.,stunted fetus)  
SPECIFIC DEVELOPMENTAL ABNORMALITIES  
Musculoskeletal system

ihl-rat TCLo:250 ppm/6H (55D pre) JTEHD6 3,965,77

EFFECTS ON FERTILITY  
Female fertility index

ihl-mus TCLo:30000 ppm/6H (5D male) EVHPAZ 21,71,77

EFFECTS ON FERTILITY  
Pre-implantation mortality

ihl-mus TCLo:500 ppm/7H (6-15D preg) EVHPAZ 41,171,81  
EFFECTS ON EMBRYO OR FETUS  
Fetotoxicity(except death,e.g.,stunted fetus)  
SPECIFIC DEVELOPMENTAL ABNORMALITIES  
Musculoskeletal system

NO SIGNIFICANT

RISK LEVEL(Ca P65): 0.3 micrograms/day

----- PROTECTION AND FIRST AID -----  
PROTECTION SUGGESTED  
FROM THE CHRIS MANUAL:

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114)  
OSHA (VINYL CHLORIDE)

Unknown, or above 3600 ppm: Open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece.

Not over 3600 ppm: Combination type C supplied air respirator, pressure demand type, with full or half facepiece, and auxiliary self-contained air supply; or

Not over 1000 ppm: Combination type, supplied air respirator continuous flow type, with full or half facepiece, and auxiliary self-contained air supply. / Type C, Supplied air respirator, continuous flow type, with full or half facepiece, helmet or hood.

Not over 100 ppm: (A) Combination type C supplied air respirator demand type; with full facepiece, and auxiliary self-contained air supply; or (B) Open-circuit self-contained breathing apparatus with full facepiece, demand mode; or (C) Type C supplied air respirator, demand type, with full facepiece.

Not over 25 ppm: (A) A powered air-purifying respirator with hood, helmet, full or half facepiece, and a canister which provides a service life of at least 4 hours for concentrations of vinyl chloride up to 25 ppm, or (B) Gas mask, front- or back-mounted canister which provides a service life of at least 4 hours for concentrations of vinyl chloride up to 25 ppm.

Not over 10 ppm: (A) Combination type C supplied-air respirator, demand type, with half facepiece, and auxiliary self-contained air supply; or (B) Type C supplied-air respirator, demand type, with half facepiece; or (C) Any chemical cartridge respirator with an organic vapor cartridge which provides a service life of at least 1 hour for concentrations of vinyl chloride up to 10 ppm.

FIRST AID (NIOSH):

EYE:

SKIN:

INHALATION:

MOVE TO FRESH AIR, KEEP QUIET AND WARM, CALL DOCTOR, ARTIFICIAL RESPIRATOR.

INGESTION:

----- INITIAL INCIDENT RESPONSE -----

DOT SHIPPING NAME: Vinyl chloride, inhibited  
T ID NUMBER: UN1086

ERG90

GUIDE 17

\* POTENTIAL HAZARDS \*

\*FIRE OR EXPLOSION

Extremely flammable.  
May be ignited by heat, sparks and flames.  
Vapors may travel to a source of ignition and flash back.  
Container may explode violently in heat of fire.  
Vapor explosion hazard indoors, outdoors or in sewers.

\*HEALTH HAZARDS

May be poisonous if inhaled.  
Contact may cause burns to skin and eyes.  
Vapors may cause dizziness or suffocation.  
Contact with liquid may cause frostbite.  
Fire may produce irritating or poisonous gases.

\* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.  
Stay upwind, out of low areas, and ventilate closed spaces before entering.  
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.  
Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire.  
CALL CHEMTREC AT 1-800-424-9300 AS SOON AS POSSIBLE, especially if there is no local hazardous team available.

\*FIRE

Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.  
Small Fires: Dry chemical or CO2.  
Large Fires: Water spray, fog or regular foam.  
Move container from fire area if you can do it without risk.  
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.  
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.  
Cool container with water using unmanned device until well after fire is out.

\*SPILL OR LEAK

Shut off ignition sources; no flares, smoking or flames in hazard area.  
Stop leak if you can do it without risk.  
Water spray may reduce vapors; but it may not prevent ignition in closed spaces.  
Isolate area until gas has dispersed.

\*FIRST AID

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.



In case of frostbite, thaw frosted parts with water.  
Keep victim quiet and maintain normal body temperature.

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## CHEMTOX DATA

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## ----- IDENTIFIERS -----

CHEMTOX RECORD 407 LAST UPDATE OF THIS RECORD: 12/03/91  
NAME: TRICHLOROETHYLENE  
SYNONYMS: TRICHLOROETHENE; ETHYLENE TRICHLORIDE; TRICLENE  
CAS: 79-01-6 RTECS: KX4550000  
FORMULA: C2HCl3 MOL WT: 131  
WLN: GYGU1G  
CHEMICAL CLASS: FT

See other identifiers listed below under Regulations.

## ----- PROPERTIES -----

PHYSICAL DESCRIPTION: COLORLESS WATERY LIQUID WITH A SWEET ODOR  
BOILING POINT: 359.82 K 86.6 C 188 F  
MELTING POINT: 187.04 K -86.2 C -123 F  
FLASH POINT: N ONE NONE NONE  
AUTO IGNITION: 683 K 409.8 C 769.7 F  
VAPOR PRESSURE: 58 MM  
UEL: 41 %  
LEL: 11 %  
IONIZATION POTENTIAL (eV): 9.47  
VAPOR DENSITY: 4.5 (air=1)  
SPECIFIC GRAVITY: 1.46 20C  
DENSITY: 1.460  
WATER SOLUBILITY: 0.1%  
INCOMPATIBILITIES: STRONG CAUSTICS; WHEN ACIDIC REACTS  
WITH ALUMINUM; CHEMICALLY ACTIVE  
METALS; BARIUM, LITHIUM, SODIUM,  
MAGNESIUM, TITANIUM  
  
REACTIVITY WITH WATER: No data on water reactivity  
REACTIVITY WITH COMMON MATERIALS: No data  
STABILITY DURING TRANSPORT: No Data  
NEUTRALIZING AGENTS: No data  
POLYMERIZATION POSSIBILITIES: No data  
  
TOXIC FIRE GASES: None reported other than possible  
unburned vapors  
ODOR DETECTED AT (ppm): 50 ppm  
ODOR DESCRIPTION: Chloroform-like; ethereal Source: CHRIS  
100 % ODOR DETECTION: No data

## ----- REGULATIONS -----

DOT hazard class: 6.1 POISON  
DOT guide: 74  
Identification number: UN1710  
Shipping name: Trichloroethylene  
Hazard group: III

Label(s) required: KEEP AWAY FROM FOOD  
Special provisions: N36,T1  
Packaging exceptions: 153  
1 bulk packaging: 203  
Bulk packaging: 241  
Quantity limitations-  
Passenger air/rail: 60 L  
Cargo aircraft only: 220 L  
Vessel stowage: A  
Other stowage provisions: 40,M2  
STCC NUMBER: 4941771

CLEAN WATER ACT Sect.307:Yes

CLEAN WATER ACT Sect.311:No

National Primary Drinking Water Regulations

Maximum Contaminant Levels (MCL): 0.005 mg/mL (01/09/89)

Maximum Contaminant Level Goals (MCLG): 0 mg/mL (01/09/89)

CLEAN AIR ACT: CAA '90 Listed

EPA WASTE NUMBER: U228,D040

CERCLA REF:

RQ DESIGNATION: B 100 pounds (45.4 kg) CERCLA

SARA TPQ VALUE: Not listed

SARA Sect. 312

categories:

Acute toxicity: Toxic. LD50 > 50 and <= 500  
mg/kg (oral rat).

Acute toxicity: adverse effect to target organs.

Chronic toxicity: adverse effect to target organ  
after long period of exposure.

STED IN SARA Sect 313: Yes

de minimus CONCENTRATION: 1.0 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: ORM-A

Mailability: Domestic service and air transportation; shipper's declaratio

Max per parcel: 10 GAL;1 PT

NFPA CODES:

HEALTH HAZARD (BLUE): (2) Hazardous to health. Area may be entered with  
self-contained breathing apparatus.

FLAMMABILITY (RED) : (1) This material must be preheated before ignition  
can occur.

REACTIVITY (YELLOW): (0) Stable even under fire conditions.

SPECIAL : Unspecified

----- TOXICITY DATA -----

SHORT TERM TOXICITY: Inhalation: HEADACHE, SLEEPINESS, NAUSEA, VOMITING,  
DIZZINESS AND COUGHING HAVE BEEN FELT AROUND 100 PPM.  
UNCONSCIOUSNESS CAN RESULT AT 3,000 PPM. EXPOSURE TO  
8,000 PPM CAN CAUSE DEATH. Skin: CAN BE ABSORBED  
THROUGH SKIN. MAY CAUSE IRRITATION, BURNING OR  
REDNESS. Eyes: MAY CAUSE IRRITATION, BURNING OR

WATERING. Ingestion: CAN CAUSE DRUNKENNESS, VOMITING, DIARRHEA OR ABDOMINAL PAIN. UNCONSCIOUSNESS, LIVER OR KIDNEY DAMAGE, VISION DISTORTION AND DEATH HAVE BEEN REPORTED AT LARGE DOSES. (NYDH)

LONG TERM TOXICITY: CONTACT WITH LEVELS NEAR 100 PPM CAN CAUSE GIDDINESS, NERVOUS EXHAUSTION, INCREASED SENSITIVITY TO ALCOHOL INCLUDING REDNESS IN THE FACE (TRICHLOROETHYLENE BLUSH), THE ABILITY TO BECOME ADDICTED TO THE VAPOR, AS WELL AS EFFECTS OF ACUTE EXPOSURE LISTED ABOVE. HIGHER LEVELS CAN ALTER ONE'S HEART RATE. REPEATED CONTACT WITH HANDS CAN CAUSE EXCESSIVE DRYNESS, CRACKING, BURNING, LOSS OF SENSE OF TOUCH OR TEMPORARY PARALYSIS OF FINGERS. MOST OF THESE EFFECTS SEEM TO GO AWAY AFTER EXPOSURE HAS STOPPED. TRICHLOROETHYLENE IS CONSIDERED A CANCER SUSPECT AGENT BECAUSE HIGH LEVELS CAUSE LIVER CANCER IN MICE. WHETHER IT CAUSES CANCER IN HUMANS IS UNKNOWN. (NYDH)

TARGET ORGANS: EYES, SKIN, NOSE, THROAT, RESP. SYSTEM, HEART, LIVER, KIDNEY;  
SYMPTOMS: INHALATION: symptoms range from irritation of the nose and throat to nausea, an attitude of irresponsibility, blurred vision, and finally disturbance of central nervous system resulting in cardiac failure. Chronic exposure may cause organic injury. INGESTION: symptoms similar to inhalation. SKIN: defatting action can cause dermatitis. EYES: slightly irritating sensation and lachrymation. Source: CHRIS

CONC IDLH: 1000ppm

OSH REL: Potential occupational carcinogen 25 ppm Time weighted averages for 8-hour exposure

ACGIH TLV: TLV = 50 ppm

ACGIH STEL: 200 ppm

OSHA PEL: Final Rule Limits:  
TWA = 50 ppm (270 mg/M3)  
STEL = 200 ppm (1080 mg/M3)

MAK INFORMATION: 50 ppm  
270 mg/M3  
Substance with systemic effects, onset of effect less than or equal to 2 hrs: Peak = 5xMAK for 30 minutes, 2 times per shift of 8 hours.  
There is no reason to fear a risk of damage to the developing embryo or fetus when MAK values are adhered to.

CARCINOGEN?: Y STATUS: ANIMAL POSITIVE

REFERENCES: ANIMAL SUSPECTED IARC\*\* 20,545,79  
ANIMAL POSITIVE IARC\*\* 11,263,76  
HUMAN INDEFINITE IARC\*\* 20,545,79

CARCINOGEN LISTS:

IARC: Not classified as to human  
carcinogenicity or probably not  
carcinogenic to humans.  
MAK: Not listed  
NIOSH: Carcinogen defined by NIOSH  
with no further categorization.  
NTP: Not listed  
ACGIH: Not listed  
OSHA: Not listed

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)

orl-hmn LDLo:7 gm/kg ARTODN 35,295,76

orl-man TDLo:2143 mg/kg 34ZIAG -,602,69  
GASTROINTESTINAL  
Other changes

ihl-hmn TCLo:6900 mg/m3/10M AHBAAM 116,131,36  
BEHAVIORAL  
Somnolence(general depressed activity)  
BEHAVIORAL  
Hallucinations, distorted perceptions

ihl-hmn TCLo:160 ppm/83M AIHAAP 23,167,62  
BEHAVIORAL  
Hallucinations, distorted perceptions

ihl-hmn TDLo:812 mg/kg BMJOAE 2,689,45  
BEHAVIORAL  
Somnolence(general depressed activity)  
GASTROINTESTINAL  
Other changes  
LIVER  
Jaundice, other or unclassified

ihl-man TCLo:110 ppm/8H BJIMAG 28,293,71  
SENSE ORGANS  
Eye  
Other  
BEHAVIORAL  
Hallucinations, distorted perceptions

LD50 value: No LD50 in RTECS 1991

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1991)

ihl-rat LC50:25700 ppm/1H  
ipr-rat LD50:1282 mg/kg  
orl-mus LD50:2402 mg/kg  
ihl-mus LC50:8450 ppm/4H  
scu-mus LD50:16 gm/kg  
ivn-mus LD50:33900 ug/kg  
ipr-dog LD50:1900 mg/kg  
scu-dog LDLo:150 mg/kg  
ivn-dog LDLo:150 mg/kg

orl-cat LDLo:5864 mg/kg  
ihl-cat LCLo:32500 mg/m3/2H  
orl-rbt LDLo:7330 mg/kg  
ihl-rbt LCLo:11000 ppm  
scu-rbt LDLo:1800 mg/kg  
ihl-gpg LCLo:37200 ppm/40M

Reproductive toxicity (1991 RTECS):

This chemical is a mammalian reproductive toxin.

REPRODUCTIVE TOXICITY DATA (1991 RTECS)

orl-rat TDLo:2688 mg/kg (1-22D preg/21D post) TOXID9  
4,179,84

EFFECTS ON NEWBORN

Behavioral

orl-rat TDLo:36 gm/kg (15D pre/1-21D preg) TXCYAC  
32,229,84

EFFECTS ON NEWBORN

Weaning or lactation index(#alive at weaning per #  
alive at day 4)

ihl-rat TCLo:1800 ppm/24H (1-20D preg) APTOD9 19,A22,80  
SPECIFIC DEVELOPMENTAL ABNORMALITIES

Musculoskeletal system

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Other developmental abnormalities

ihl-rat TCLo:100 ppm/4H (6-22D preg) JPHYA7 276,24P,78  
EFFECTS ON FERTILITY

Post-implantation mortality

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

ihl-rat TCLo:1800 ppm/6H (1-20D preg) TXCYAC 14,153,79  
SPECIFIC DEVELOPMENTAL ABNORMALITIES

Urogenital system

ihl-rat TCLo:100 ppm/4H (8-21D preg) BJANAD 54,337,82  
SPECIFIC DEVELOPMENTAL ABNORMALITIES

Musculoskeletal system

ihl-mus TCLo:100 ppm/7H (5D male) NTIS\*\* PB82-185075  
PATERNAL EFFECTS

Spermatogenesis

NO SIGNIFICANT

RISK LEVEL(Ca P65): 60 micrograms/day

----- PROTECTION AND FIRST AID -----

PROTECTION SUGGESTED

FROM THE CHRIS MANUAL:

**\*\* WEAR APPROPRIATE EQUIPMENT TO PREVENT:**

Repeated or prolonged skin contact.

**WEAR EYE PROTECTION TO PREVENT:**

Reasonable probability of eye contact.

**\*\* EXPOSED PERSONNEL SHOULD WASH:**

Promptly when skin becomes wet.

**\*\* REMOVE CLOTHING:**

Promptly remove non-impervious clothing that becomes wet.

**\*\* REFERENCE: NIOSH**

**RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114)  
NIOSH (TRICHLOROETHYLENE)**

Greater at any detectable concentration. : Any self-contained breathing apparatus with full facepiece and operated in a pressure-demand or other positive pressure mode. / Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

ESCAPE: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. / Any appropriate escape-type self-contained breathing apparatus.

**FIRST AID (NIOSH):**

E:

IRR IMMED

N:

SOAP WASH PROMPTLY

**INHALATION:**

ART RESP

**INGESTION:**

IPECAC, VOMIT

----- INITIAL INCIDENT RESPONSE -----

US Department of Transportation Guide to Hazardous Materials Transport  
Information - Publication DOT 5800.5 (1990).

DOT SHIPPING NAME: Trichloroethylene

DOT ID NUMBER: UN1710

ERG90

GUIDE 74

**\* POTENTIAL HAZARDS \***

**\*HEALTH HAZARDS**

Vapors may cause dizziness or suffocation.

Exposure in an enclosed area may be very harmful.

Contact may irritate or burn skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

**\*FIRE OR EXPLOSION**

Some of these materials may burn, but none of them ignites readily.

Most vapors heavier than air.

Air/vapor mixtures may explode when ignited.  
Container may explode in heat of fire.

\* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.  
Stay upwind, out of low areas, and ventilate closed spaces before entering.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Isolate 1/2 mile in all directions if tank, rail car or tank truck is involved in fire.

Remove and isolate contaminated clothing at the site.

CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE.

If water pollution occurs, notify the appropriate authorities.

\*FIRE

Small Fires: Dry chemical or CO2.

Large Fires: Water spray, fog or regular foam.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

\*SPILL OR LEAK

Shut off ignition sources; no flares, smoking or flames in hazard area.  
Stop leak if you can do it without risk.

Small Liquid Spills: Take up with sand, earth or other noncombustible absorbent material.

Large Spills: Dike far ahead of liquid spill for later disposal.

\*FIRST AID

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

Use first aid treatment according to the nature of the injury.

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## ----- IDENTIFIERS -----

CHEMTOX RECORD 247  
NAME: LEAD  
SYNONYMS: C.I. PIGMENT METAL 4; C.I. 77575; KS-4; LEAD FLAKE; LEAD  
S2; OLOW (Polish); SI; SO  
CAS: 7439-92-1 RTECS: OF7525000  
FORMULA: Pb MOL WT: 207.19  
WLN: PB  
CHEMICAL CLASS: Metal

LAST UPDATE OF THIS RECORD: 06/03/93

See other identifiers listed below under Regulations.

## ----- PROPERTIES -----

PHYSICAL DESCRIPTION: bluish-grey, soft metal; heavy ductile, soft, gray  
solid

BOILING POINT:	2013 K	1739.8 C	3163.7 F
MELTING POINT:	600.6 K	327.4 C	621.4 F
FLASH POINT:	NA		
AUTO IGNITION:	NA		
VAPOR PRESSURE:	1mm @ 973 C		
UEL:	NA		
LEL:	NA		
VAPOR DENSITY:	No data		
SPECIFIC GRAVITY:	11.34		
DENSITY:	11.34 g/mL @ 20 C		
WATER SOLUBILITY:	INSOLUBLE; DISSOLVES SLOWLY IN WATER CONTAINING A WEAK ACID		
INCOMPATIBILITIES:	strong ox, hydrogen peroxide, active metals, sodium, potassium, chlorine trifluoride, hydrogen peroxide, zirconium, disodium acetylide, oxidants		
REACTIVITY WITH WATER:	No data on water reactivity		
REACTIVITY WITH COMMON MATERIALS:	RELATIVELY IMPENETRABLE TO RADIATION		
STABILITY DURING TRANSPORT:	No Data		
NEUTRALIZING AGENTS:	No data		
POLYMERIZATION POSSIBILITIES:	No data		
TOXIC FIRE GASES:	WHEN HEATED EMITS HIGHLY TOXIC FUMES; CAN REACT VIGOROUSLY WITH OXIDIZING MATERIALS		
ODOR DETECTED AT (ppm):	Unknown		
ODOR DESCRIPTION:	No data		
100 % ODOR DETECTION:	No data		

## ----- REGULATIONS -----

National Primary Ambient Air Quality Standards  
1.5 ug/M3 maximum arithmetic mean averaged over a calendar year  
National Secondary Ambient Air Quality Standards  
as primary standard

DOT hazard class: 6.1 POISON  
DOT guide: 53  
Identification number: UN2291  
DOT shipping name: LEAD COMPOUNDS, SOLUBLE, N.O.S.  
Packing group: II  
Label(s) required: POISON  
Special provisions:  
Packaging exceptions: 173.153  
Non bulk packaging: 173.213  
Bulk packaging: 173.240  
Quantity limitations-  
Passenger air/rail: 100 KG  
Cargo aircraft only: 200 KG  
Vessel stowage: A  
Other stowage provisions:

STCC NUMBER: Not listed

CLEAN WATER ACT Sect.307:Yes

CLEAN WATER ACT Sect.311:No

National Primary Drinking Water Regulations

Maximum Contaminant Levels (MCL): 0.05 mg/L (12/07/92)

Maximum Contaminant Level Goals (MCLG): 0 mg/L (12/07/92)

AIR ACT: CAA '90 By category and CAA '77 Sect 109

WASTE NUMBER: D008

CERCLA REF: Y

RQ DESIGNATION: X 1 pound (0.454 kg) CERCLA for pieces of solid metal  
with diameter less than 100 micrometers (0.004  
inches).

SARA TPQ VALUE: Not listed

SARA Sect. 312  
categories:

Chronic toxicity: carcinogen  
Chronic toxicity: adverse effect to target organ  
after long period of exposure.  
Chronic toxicity: mutagen.  
Chronic toxicity: reproductive toxin.

LISTED IN SARA Sect 313: Yes  
de minimus CONCENTRATION: 0.1 percent

UNITED STATES POSTAL SERVICE MAILABILITY:

Hazard class: ORM-B  
Mailability: Domestic service and air transportation; shipper's declaration  
Max per parcel: 25 LBS; 5 LBS

NFPA CODES:

HEALTH HAZARD (BLUE): Unspecified  
FLAMMABILITY (RED) : Unspecified  
REACTIVITY (YELLOW): Unspecified  
SPECIAL : Unspecified

----- SUMMARY OF REGULATORY LISTS THIS SUBSTANCE APPEARS ON -----

ACGIH TLV list "Threshold Limit Values for 1989-1990"  
California Assembly Bill 2588 Air Toxics "Hot Spots" Chemicals.  
California Assembly Bill 1807 Toxic Air Contaminants.  
California Proposition 65 Developmental Toxin List  
California Proposition 65 Female Reproductive Toxin List  
California Proposition 65 Male Reproductive Toxin List  
Canadian Ingredient Disclosure List. 20/01/88 Canada Gazette part II, Vol 122.  
Clean Air Act Section 109 National Ambient Air Quality Standards List  
Clean Air Act of November 15, 1990. List of pollutants.  
Clean Water Act Section 307 Priority Pollutants  
DOT Marine Pollutant. Proposed list. 57 FR 3854, Jan 31, 1992  
EPA TSCA Chemical Inventory List 1986  
EPA TSCA Chemical Inventory List 1989  
EPA TSCA Chemical Inventory List 1990  
EPA TSCA Chemical Inventory List 1992  
EPA TSCA Test Submission (TSCATS) Database - April 1990  
EPA TSCA Test Submission (TSCATS) Database - September 1989  
LEAD [7439-92-1]  
Massachusetts Substance List.  
New Jersey DEQ100 list for release reporting.  
New Jersey Right To Know Substance List. (December 1987)  
New Jersey Right to Know Substance List. Listed as a teratogen.  
California Air Contaminant (Table Z-1-A). 54 FR 4332, Jan. 19, 1989 and revised.  
OSHA Specifically regulated substance. See 29 CFR 1910.1025  
Pennsylvania Hazardous Substance List  
RCRA Hazardous Waste  
RCRA Toxicity Characteristics (TC) list dated March 29, 1990  
SARA Section 313 Toxic Chemicals List

----- TOXICITY DATA -----

SHORT TERM TOXICITY: LASSITUDE, INSOMNIA, PALLOR, EYE GROUND, ANOREXIA,  
LOW-WEIGHT, MALNUTRITION, CONSTIPATION, ABDOMINAL  
PAIN, COLIC; HYPOTENSE, ANEMIA; GINGIVAL LEAD LINE;  
TREMBLING PARALYSIS WRIST. \*\* Source: 2

LONG TERM TOXICITY: unknown

TARGET ORGANS: gi, CNS, kidneys, blood, gingival tissue

SYMPTOMS: LASS, INSOM, PAL, EYE GROUND, ANOR, LOW-WT, MALNUT,  
CONSTI, ABDOM PAIN, COLIC; HYPOTENSE, ANEMIA, GINGIVAL  
LEAD LINE; TREM, PARA WRIST. METALLIC TASTE, INCREASED  
SALIVATION, PYORRHEA (FLOW OF MUCOUS). NEUROMUSCULAR:  
NUMBNESS AND TINGLING OF EXTREMITIES WITH SENSORY

DISTRUBANCE, EXTENSOR WEAKNESS OF WRISTS AND ANKLES, LOSS OF MUSCLE TONE, TREMOR INCREASED DEEP-TENDON REFLEXES, MUSCULAR CRAMPS AND ACHING, MUSCULAR ATROPHY. CNS: VISUAL DISTURBANCES, HEADACHE, NERVOUSNESS OF DEPRESSION, INSOMNIA, MENTAL CONFUSION, DELIRIUM. Source: NIOSHP, THIC

CONC IDLH: 700mg/M3

NIOSH REL: <0.1 mg/M3 Air level to be maintained so that worker blood level remains <0.06 mg/100 g of whole blood

ACGIH TLV: TLV = 0.15mg/M3

ACGIH STEL: Not listed

OSHA PEL: Final Rule Limits:  
TWA = See 29 CFR 1910.1025  
50 ug/M3

MAK INFORMATION: 0.1 mg/M3  
Substance with systemic effects, onset of effect over 2 hours: Peak = 10xMAK for 30 minutes, once per shift of 8 hours.

CARCINOGEN?: Y STATUS: See below

CARCINOGEN LISTS:

IARC: Carcinogen defined by IARC  
to be possibly carcinogenic to  
humans, but having (usually) no  
human evidence.

MAK: Not listed

NIOSH: Not listed

NTP: Not listed

ACGIH: Not listed

OSHA: Not listed

HUMAN TOXICITY DATA: (Source: NIOSH RTECS)  
orl-wmn TDLo:450 mg/kg/6Y JAMAAP 237,2627,77  
PERIPHERAL NERVE AND SENSATION  
Flaccid paralysis without anesthesia  
BEHAVIORAL  
Hallucinations, distorted perceptions  
BEHAVIORAL  
Muscle weakness

LD50 value: No LD50 in RTECS 1992

OTHER SPECIES TOXICITY DATA: (Source: NIOSH RTECS 1992)

ipr-rat LDLo:1 gm/kg

orl-pgn LDLo:160 mg/kg

IRRITATION DATA: (Source: NIOSH RTECS 1992)

Reproductive toxicity (1992 RTECS):

This chemical is a mammalian reproductive toxin.

REPRODUCTIVE TOXICITY DATA (1992 RTECS)

orl-rat TDLo:790 mg/kg (multigenerations) AEHLAU  
23,102,71

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

EFFECTS ON EMBRYO OR FETUS

Fetal death

orl-rat TDLo:1140 mg/kg (14D pre-21D post) PHMCAA  
20,201,78

EFFECTS ON NEWBORN

Behavioral

orl-rat TDLo:520 mg/kg (7-22D preg/10D post) FEPR7  
37,394,78

EFFECTS ON NEWBORN

orl-rat TDLo:1100 mg/kg (1-22D preg) FEPR7 37,895,78  
SPECIFIC DEVELOPMENTAL ABNORMALITIES  
Blood and lymphatic systems(including spleen and  
marrow)

EFFECTS ON NEWBORN

Growth statistics(e.g.,reduced weight gain)

ihl-rat TClO:10 mg/m3/24H (1-21D preg) ZHPMAT  
165,294,77

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Blood and lymphatic systems(including spleen and  
marrow)

ihl-rat TClO:3 mg/m3/24H (1-21D preg) ZHPMAT 165,294,77  
EFFECTS ON NEWBORN

orl-mus TDLo:1120 mg/kg (multigenerations) AEHLAU  
23,102,71

EFFECTS ON EMBRYO OR FETUS

Fetotoxicity(except death,e.g.,stunted fetus)

EFFECTS ON EMBRYO OR FETUS

Fetal death

orl-mus TDLo:6300 mg/kg (1-21D preg) EXPEAM 31,1312,75  
EFFECTS ON FERTILITY

Female fertility index  
EFFECTS ON FERTILITY  
Pre-implantation mortality

orl-mus TDLo:300 mg/kg (1-2D preg) TXCYAC 6,129,76  
EFFECTS ON FERTILITY  
Other measures of fertility

orl-mus TDLo:4800 mg/kg (1-16D preg) BECTA6 18,271,77  
EFFECTS ON EMBRYO OR FETUS  
Cytological changes(including somatic cell genetic material)

orl-dom TDLo:662 mg/kg (1-21W preg) TXAPA9 25,466,73  
EFFECTS ON NEWBORN  
Behavioral

NO SIGNIFICANT

RISK LEVEL(Ca P65): E0.5 micrograms/day

----- EPA's IRIS DATA SUMMARY -----  
Lead and compounds (inorganic); CASRN 7439-92-1 (04/01/92)

## II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- Lead and compounds (inorganic)

CASRN -- 7439-92-1

Last Revised -- 05/01/91

Section II provides information on three aspects of the carcinogenic risk assessment for the agent in question; the U.S. EPA classification, and quantitative estimates of risk from oral exposure and from inhalation exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. Background Document 2 (Service Code 5) provides details on the rationale and methods used to derive the carcinogenicity values found in IRIS. Users are referred to Section I for information on long-term toxic effects other than carcinogenicity.

### II.A. EVIDENCE FOR CLASSIFICATION AS TO HUMAN CARCINOGENICITY

#### II.A.1. WEIGHT-OF-EVIDENCE CLASSIFICATION

Classification -- B2; probable human carcinogen

Basis -- Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that lead affects gene expression. Human evidence is inadequate.

#### II.A.2. HUMAN CARCINOGENICITY DATA

Inadequate. There are four epidemiologic studies of occupational cohorts exposed to lead and lead compounds. Two studies (Dingwall-Fordyce and Lane, 1963; Nelson et al., 1982) did not find any association between exposure and cancer mortality. Selevan et al. (1985), in their retrospective cohort mortality study of primary lead smelter workers, found a slight decrease in the total cancer mortality (SMR=95). Apparent excesses were observed for respiratory cancer (SMR=111, obs=41,  $p>0.05$ ) and kidney cancer (SMR=204, obs=6,  $p>0.05$ ). Cooper and Gaffey (1975) and Cooper (1985 update) performed a cohort mortality study of battery plant workers and lead smelter workers. They found statistically significant excesses for total cancer mortality (SMR=113, obs=344), stomach cancer (SMR=168, obs=34), and lung cancer (SMR=124, obs=109) in the battery plant workers. Although similar excesses were observed in the smelter workers, they were not statistically significant. Cooper and Gaffey (1975) felt it was possible that individual subjects were monitored primarily on the basis of obvious signs of lead exposure, while others who showed no symptoms of lead poisoning were not monitored.

All of the available studies lacked quantitative exposure information, as well as information on the possible contribution from smoking. All studies also included exposures to other metals such as arsenic, cadmium, and zinc for which no adjustment was done. The cancer excesses observed in the lung and stomach were relatively small ( $<200$ ). There was no consistency of site among the various studies, and no study showed any dose-response relationship. Thus, the available human evidence is considered to be inadequate to refute or demonstrate any potential carcinogenicity for humans from lead exposure.

#### II.A.3. ANIMAL CARCINOGENICITY DATA

Sufficient. The carcinogenic potential of lead salts (primarily phosphates and acetates) administered via the oral route or by injection has been demonstrated in rats and mice by more than 10 investigators. The most characteristic cancer response is bilateral renal carcinoma. Rats given lead acetate or subacetate orally have developed gliomas, and lead subacetate also produced lung adenomas in mice after i.p. administration. Most of these investigations found a carcinogenic response only at the highest dose. The lead compounds tested in animals are almost all soluble salts. Metallic lead, lead oxide and lead tetraalkyls have not been tested adequately. Studies of inhalation exposure have not been located in the literature.

Azar et al. (1973) administered 10, 50, 100, and 500 ppm lead as lead

acetate in dietary concentrations to 50 rats/sex/group for 2 years. Control rats (100/sex) received the basal laboratory diet. In a second 2-year feeding study, 20 rats/group were given diets containing 0, 1000, and 2000 ppm lead as lead acetate. No renal tumors were reported in the control groups or in treated animals of either sex receiving 10 to 100 ppm. Male rats fed 500, 1000, and 2000 ppm lead acetate had an increased renal tumor incidence of 5/50, 10/20, and 16/20, while 7/20 females in the 2000-ppm group developed renal tumors.

The Azar et al. (1973) study is limited by the lack of experimental detail. The possibility of environmental contamination from lead in the air or drinking water was not mentioned. The strains of rats used were not specified in the study, but the Health Effects Assessment for Lead (U.S. EPA, 1984) indicates the rats were Wistar strain. The weight gain at 1000 and 2000 ppm was reported to be depressed, but details were not given.

Kasprzak et al. (1985), in investigating the interaction of dietary calcium on lead carcinogenicity, fed 1% lead subacetate (8500 ppm Pb) to male Sprague-Dawley rats in the diet for 79 weeks. Of the rats surviving (29/30) in this treatment group beyond 58 weeks, 44.8% had renal tumors. Four rats had adenocarcinomas; the remaining nine had adenomas. Bilateral tumors were noted. No renal tumors were noted among the controls.

As part of a study to determine interactions between sodium nitrite, ethyl urea and lead, male Sprague-Dawley rats were given lead acetate in their drinking water for 76 weeks (Koller et al., 1986). The concentration of lead was 2600 ppm. No kidney tumors were detected among the 10 control rats. Thirteen of 16 (81%) lead-treated rats had renal tubular carcinoma; three tumors were detected at 72 weeks and the remainder detected at the termination of the study.

Van Esch and Kroes (1969) fed basic lead acetate at 0, 0.1%, and 1.0% in the diet to 25 Swiss mice/sex/group for 2 years. No renal tumors developed in the control group, but 6/25 male mice of 0.1% basic lead acetate group had renal tumors (adenomas and carcinomas combined). In the 1.0% group, one female had a renal tumor. The authors thought that the low incidence in the 1.0% group was due to early mortality.

Hamsters given lead subacetate at 0.5% and 1% in the diet had no significant renal tumor response (Van Esch and Kroes, 1969).

#### II.A.4. SUPPORTING DATA FOR CARCINOGENICITY

Lead acetate induces cell transformation in Syrian hamster embryo cells (DiPaolo et al., 1978) and also enhances the incidence of simian adenovirus induction. Lead oxide showed similar enhanced adenovirus induction (Casto et al., 1979).

Under certain conditions lead compounds are capable of inducing chromosomal aberrations in vivo and in tissue cultures. Grandjean et al. (1983) showed a relationship between SCE and lead exposure in exposed workers.



Lead has been shown, in a number of DNA structure and function assays, to affect the molecular processes associated with the regulation of gene expression (U.S. EPA, 1986).

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II.B. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM ORAL EXPOSURE

Not available.

Quantifying lead's cancer risk involves many uncertainties, some of which may be unique to lead. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. In addition, current knowledge of lead pharmacokinetics indicates that an estimate derived by standard procedures would not truly describe the potential risk. Thus, the Carcinogen Assessment Group recommends that a numerical estimate not be used.

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II.C. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM INHALATION EXPOSURE

Not available.

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II.D. EPA DOCUMENTATION, REVIEW, AND CONTACTS (CARCINOGENICITY ASSESSMENT)

II.D.1. EPA DOCUMENTATION

U.S. EPA. 1984. Health Effects Assessment for Lead. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-86/055. NTIS PB85-163996/AS.

U.S. EPA. 1986. Air Quality Criteria Document for Lead. Volumes III, IV. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC, for the Office of Air Quality Planning and Standards. EPA-600/8-83/028dF.

U.S. EPA. 1987. Preliminary review of the carcinogenic potential of lead associated with oral exposure. Prepared by the Office of Health and Environmental Assessment, Carcinogenic Assessment Group, Washington DC, for the Office of Drinking Water, Office of Solid Waste and the Office of Emergency and Remedial Response (Superfund). OHEA-C-267. Internal Review Draft.

II.D.2. REVIEW (CARCINOGENICITY ASSESSMENT)

The review of the carcinogenic potential of lead associated with oral exposure has received Agency review.

The 1986 Air Quality Criteria Document for Lead has received Agency and External Review.

Agency Work Group Review: 05/04/88

Verification Date: 05/04/88

II.D.3. U.S. EPA CONTACTS (CARCINOGENICITY ASSESSMENT)

William Pepelko / ORD -- (202)260-5898 / FTS 260-5898

James Cogliano / ORD -- (202)260-9243 / FTS 260-9243

----- PROTECTION AND FIRST AID -----

PROTECTION SUGGESTED

1 THE CHRIS MANUAL:

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS:

\*\* WEAR APPROPRIATE EQUIPMENT TO PREVENT:  
Repeated or prolonged skin contact.

\*\* WEAR EYE PROTECTION TO PREVENT:  
Reasonable probability of eye contact.

\*\* EXPOSED PERSONNEL SHOULD WASH:  
At the end of each work shift.

\*\* REMOVE CLOTHING:  
Promptly remove non-impervious clothing that becomes contaminated.

\*\* REFERENCE: NIOSH

RECOMMENDED RESPIRATION PROTECTION Source: NIOSH POCKET GUIDE (85-114)  
OSHA (LEAD)

Not in excess of 0.5 mg/M3: Half-mask, air-purifying respirator  
equipped with high efficiency filters.

Not in excess of 2.5 mg/M3: Full facepiece air-purifying respirator  
equipped with high-efficiency filters.

Not in excess of 50 mg/M3: (1) Any powered, air-purifying respirator with high efficiency filters; or (2) Half-mask supplied-air respirator operated in positive-pressure mode.

. . . in excess of 100 mg/M3: Supplied air respirator with full facepiece hood, or helmet or suit and operated in positive pressure mode.

Unknown concentration or Firefighting: Full facepiece, self-contained breathing apparatus operated in postive-pressure mode.

FIRST AID SOURCE: NIOSH

EYE: irr immed

SKIN: soap flush promptly

INHALATION: art resp

INGESTION: water, vomit

FIRST AID SOURCE: DOT Emergency Response Guide 1990.

Move victim to fresh air; call emergency medical care. In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Remove and isolate contaminated clothing and shoes at the site.

----- INITIAL INCIDENT RESPONSE -----

US Department of Transportation Guide to Hazardous Materials Transport Information - Publication DOT 5800.5 (1990).

DOT SHIPPING NAME: LEAD COMPOUNDS, SOLUBLE, N.O.S.

DOT ID NUMBER: UN2291

ERG90

GUIDE 53

\* POTENTIAL HAZARDS \*

\*HEALTH HAZARDS

Poisonous if swallowed.

Inhalation of dust poisonous.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

\*FIRE OR EXPLOSION

Some of these materials may burn, but none of them ignites readily.

\* EMERGENCY ACTION \*

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities.

\*FIRE

Small Fires: Dry chemical, CO2, water spray or regular foam.

Large Fires: Water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

\*SPILL OR LEAK

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Small Spills: Take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Small Dry Spills: With clean shovel place material into clean, dry container and cover; move containers from spill area.

Large Spills: Dike far ahead of liquid spill for later disposal.

\*FIRST AID

Move victim to fresh air; call emergency medical care.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement. The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms.

**Attachment 2**  
**Accident Report Form**

# ACCIDENT REPORT FORM

SUPERVISORS REPORT OF ACCIDENT		DO NOT USE FOR MOTOR VEHICLE OR AIRCRAFT ACCIDENTS	
TO		FROM	
		TELEPHONE (Include area code)	
NAME OF INJURED OR ILL WORKER AND COMPANY			
WORKER'S SOCIAL SECURITY NUMBER			
DATE OF ACCIDENT	TIME OF ACCIDENT	EXACT LOCATION OF ACCIDENT	
NARRATIVE DESCRIPTION OF ACCIDENT			
NATURE OF ILLNESS OR INJURY AND PART OF BODY INVOLVED			<b>LOST TIME</b>  YES <input type="checkbox"/> NO <input type="checkbox"/>
PROBABLE DISABILITY (Check one)			
FATAL <input type="checkbox"/>	LOST WORK DAY WITH ____ DAYS AWAY FROM WORK	LOST WORK DAY WITH ____ DAYS OF RESTRICTED ACTIVITY	NO LOST WORK DAY <input type="checkbox"/>  FIRST-AID ONLY <input type="checkbox"/>
CORRECTIVE ACTION RECOMMENDED (By whom and by when)			
NAME OF SUPERVISOR		TITLE	
SIGNATURE		DATE	

**Attachment 3**  
**Drilling Safety Guidelines**

## APPENDIX J

**Drilling Safety Guide**

Drilling Safety Guide .....	B-2
Drill Rig Safety Supervisor .....	B-2
Drill Rig Personnel Protective Equipment .....	B-3
Drill Rig Housekeeping .....	B-3
Maintenance Safety .....	B-4
Safe Use of Hand Tools .....	B-4
Safety During Drilling Operations .....	B-5
Working on Derrick Platforms .....	B-6
Working on the Ground .....	B-6
Wire Rope Safety .....	B-7
Cathead and Rope Hoist Safety .....	B-8
Auger Safety .....	B-9
Rotary and Core Drilling Safety .....	B-9



**Drill Rig Personnel Protective Equipment**

For most geotechnical, mineral, and/or groundwater drilling, drill rig personal protective equipment will include the following:

- Hard hat
- Safety shoes with steel toe and steel shank (or equivalent)
- Gloves
- Safety glasses with side shields
- Close-fitting but comfortable clothes
- Hearing protection

It is important that clothing does not have loose ends, straps, drawstrings or belts, or other unfastened parts that might become caught in or on a rotating or translating part of the drill rig.

Rings, necklaces, or other jewelry will not be worn during drilling operations.

Additional protective equipment may be required by the Site-Specific Health and Safety Plan.

**Drill Rig Housekeeping**

The following housekeeping measures must be taken for all drilling operations.

- Suitable storage locations will be provided for all tools, materials, and supplies. The storage should be conveniently located and will provide for safe handling of all supplies.
- Drill tools, supplies, and materials will not be transported on the drill rig unless the drill rig is designed and equipped to carry drill tools, supplies, and materials.
- Pipe, drill rods, casing, augers, and similar drilling tools when stored will be stacked in a manner that will prevent spreading, rolling, or sliding.
- Penetration or other driving hammers will be secured to prevent movement when not in use.
- Work areas, platforms, walkways, scaffolding, and other access ways will be kept free of materials, debris and obstructions and substances such as ice, grease, or oil that could cause a surface to become slick or otherwise hazardous.
- Never store gasoline in a nonapproved container. Red, nonsparking, vented containers marked with the word gasoline will be used. The fill spout will have a flame arrester.
- Prior to drilling, adequate site clearing and leveling will be performed to accommodate the drill rig and supplies and to provide a safe working area. Drilling will not be started when tree limbs, unstable ground or site obstructions cause unsafe tool handling conditions.

off device. Always assume that you may lose your footing. To avoid serious injury if you fall, remove sharp objects from the area near you.

- Keep all pipe wrenches clean and in good repair. The jaws of pipe wrenches will be wire brushed frequently to prevent accumulation of dirt and grease which cause wrenches to slip.
- Never use pipe wrenches in place of a rod holding device.
- Replace hock and heel jaws when visibly worn.
- When breaking tool joints on the ground or on a drilling platform, position hands so that fingers will not be smashed between the wrench handle and the ground or the platform if the wrench were to slip or the joint suddenly to let go.

### **Safety During Drilling Operations**

- Do not drive a drill rig from hole to hole with the mast (derrick) in the raised position.
- Before raising the mast, look up to check for overhead obstructions.
- Before raising the mast, all drill rig personnel (except the person raising the mast) and visitors will be cleared from the area immediately to the rear and sides of the mast. All drill rig personnel and visitors will be informed that the mast is being raised prior to raising the mast.
- All drill rig personnel and visitors will be instructed to stand clear of the drill rig immediately prior to and during starting of the engine.
- All gear boxes will be in the neutral position, all hoist levers will be disengaged, all hydraulic levers will be in the nonactuating positions, and the cathead rope will not be on the cathead before starting the drill rig engine.
- The drill rig must be leveled and stabilized with leveling jacks and/or solid cribbing before the mast is raised. The drill rig will be leveled if settling occurs after initial setup.
- The mast will be lowered only when the leveling jacks are down. The leveling jacks must be in the down position until the mast is completely lowered.
- Secure and/or lock the mast according to the drill rig manufacturer's recommendations before starting drilling operations.
- The drill rig must only be operated from the control position. If the operator must leave the control position, the rotary drive and the feed control must be placed in the neutral position. The drill engine will be shut down when the operator leaves the vicinity of the drill rig.
- Throwing or dropping of tools is not permitted. All tools will be carefully passed by hand between personnel or a hoist line will be used.
- When drilling within an enclosed area, ensure that fumes are exhausted out of the area. Exhaust fumes can be toxic and may not be detected by smell.
- Clean mud and grease from boots before mounting the drill platform. Use hand holds and railings. Watch for slippery ground when dismounting from the drill platform.
- Do not touch any metal parts of the drill rig with exposed flesh during freezing weather. Freezing of moist skin to metal can occur almost instantaneously.
- All unattended boreholes must be covered or otherwise protected to prevent drill rig personnel, site visitors, or animals from stepping or falling into the hole.

- While in transit with boom lowered and no load, the equipment clearance will be a minimum of 4 feet for voltages less than 50kv, 10 feet for voltages 51kv to 345kv, and 16 feet for voltages over 345kv.
- Before working near transmitter towers where an electrical charge can be induced in the equipment or materials being handled, the transmitter will be de-energized. The following precautions will be taken to dissipate induced voltages:
  - The equipment will be provided with an electrical ground to the upper rotating structure supporting the boom.
  - Ground jumper cables will be attached to materials being handled by boom equipment when electrical charge may be induced while working near energized transmitters. Crews will be provided nonconductive poles having large alligator clips or other similar protection to attach the ground cable to the load. Insulating gloves will be used.
- Continue to watch overhead power lines. Both hoist lines and overhead power lines can be moved toward each other by the wind.
- If there are any questions concerning drill rig operations on a site in the vicinity of overhead power lines, call the power company. The power company will provide expert advice as a public service.
- Look for warning signs indicating underground utilities. Underground utilities may be located a considerable distance away from the warning sign. Call the utility and jointly determine the precise location of all underground utility lines, mark and flag the locations, and determine the specific precautions to be taken to ensure safe drilling operations.

### Wire Rope Safety

- All wire ropes and fittings will be visually inspected at least once a week for abrasion, broken wires, wear, reduction in rope diameter, reduction in wire diameter, fatigue, corrosion, damage from heat, improper reeving, jamming, crushing, bird caging, kinking, core protrusion, and damage to lifting hardware.
- Wire ropes must be replaced when inspection indicates excessive damage. The *Wire Rope User's Manual* may be used as a guide for determining excessive damage.
- Wire ropes that have not been used for a period of a month or more will be thoroughly inspected before being returned to service.
- All manufactured and end fittings and connections must be installed according to the manufacturer's specifications.
- Swivel bearings on ball-bearing type hoisting swivels must be inspected and lubricated daily to ensure that the swivel rotates freely under load.
- Do not drill through or rotate drill through a slipping device, do not hoist more than 10 feet of the drill rod column above the top of the last (mast), do not hoist a rod column with loose tool joints, and do not make up, tighten, or loosen tool hoists while the rod column is being supported by a rod slipping device.

- A minimum of 18 inches must be maintained between the operating hand and the cathead drum when driving samplers, casing, or other tools. Be aware that the rope advances toward the cathead with each hammer blow as the sampler or other drilling tool advances into the ground. Loosen grip on the rope as the hammer falls. Maintaining a tight grip on the rope increases the chances of being pulled into the cathead.
- Do not use a rope that is longer than necessary. A rope that is too long can form a ground loop or otherwise become entangled with the operator's legs.
- Do not leave a cathead unattended with the rope wrapped on the drum.
- Position all other hoist lines to prevent contact with the operating cathead rope.
- The cathead operator must be on a level surface with good, firm footing conditions.

**Auger Safety**

- The drill rig must be level, the clutch or hydraulic rotation control disengaged, the transmission in low gear and the engine running at low RPM when starting an auger boring.
- Seat the auger head below the ground surface with an adequate amount of downward pressure prior to rotation.
- Observe the auger head while slowly engaging the clutch or rotation control and start rotation. Stay clear of the auger.
- Slowly rotate the auger and auger head while continuing to apply downward pressure. Keep one hand on the clutch or the rotation control at all times until the auger has penetrated about one foot or more below the surface.
- Follow manufacturer's recommended methods for securing the auger to the power coupling.
- Never place hands or fingers under the bottom of an auger section when hoisting the auger over the top of the auger section in the ground or other hard surfaces such as the drill rig platform.
- Never place feet under the auger section that is being hoisted.
- Stay clear of rotating augers and other rotating components of the drill rig.
- Never reach behind or around a rotating auger.
- Use a long-handle shovel to move auger cuttings away from the auger.
- Augers will be cleaned only when the drill rig is in neutral and the augers have stopped rotating.

**Rotary and Core Drilling Safety**

- Water swivels and hoist plugs must be lubricated and checked for frozen bearings before use.
- Drill rod chuck jaws must be checked periodically and replaced as necessary.
- The weight of the drill rod string and other expected hoist loads must not exceed the hoist and sheave capacities.
- Only the operator of the drill rig will brake or set a manual chuck to ensure that rotation of the chuck will not occur prior to removing the wrench from the chuck.